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*Cutting*



ART. I.—*On the occurrence of Non-union after Fractures; its Causes and Treatment.* By GEORGE W. NORRIS, M.D. One of the Surgeons to the Pennsylvania Hospital.

FEW subjects in surgery possess so much interest and importance, or have more justly exercised the pens of writers, than injuries to the bones with their consequences, and yet we find at this day many points in relation to them demanding further investigation. Of this kind, is that state of parts following upon a solution of continuity in the bony structure, termed un-united fracture, the causes, pathology, treatment, &c. of which, are all matters upon which very indefinite ideas are held by the great mass of practitioners. Having had my attention particularly drawn to the subject, and finding the great contrariety of opinion that existed among writers and practitioners in regard to the best mode of treatment of this state of parts, I collected together a table of as many of the more complete cases as I found recorded in the works within my reach, with a view to their analysis, for the purpose of satisfying myself on this important point.

The tables, together with the analysis made of them, have been very carefully drawn out, and believing them to possess interest, I have ventured to arrange them for publication, in connection with other matter on the subject with which their analysis, and my reading, and personal observations, have furnished me. The single cases which at long intervals meet the eye of the reader, like the results of treatment given by practitioners from recollection alone, not unfrequently mislead us, and I am inclined to think, were

the scattered facts which we find recorded in our science more frequently collected together in tabular forms, compared, and analyzed, that we would be furnished with much valuable information of which we are now deprived. I am well aware that many objections have been urged to this mode of arriving at conclusions. In surgery, unhappily, we are all too prone to silence in regard to our unfortunate cases, while it is rare that success after any operation at all out of the common course, is not made known. This forms the ground of the most weighty of the objections that can be brought against the mode of arriving at results which we have followed, as by any table of published cases of any particular treatment that may be drawn out, the conclusions furnished will be much too favourable, in consequence of the fortunate cases only (generally speaking) being found recorded. We acknowledge this objection to have weight, but nevertheless look upon even an approach to certain results as of some value, and regard the method employed, when cautiously done, as one of the modes by which sure improvement in our science is to be made.

As a general rule, fractured bones unite readily; and it may be safely averred that the occurrence of false joint after these accidents is not common. In his paper on the use of vesicatories in this state of parts, Mr. Walker of Oxford (*Lond. Med. and Phys. Journ.* xxxii, 1815) affirms that he has attended the reduction and after treatment of not less than one thousand fractures, including simple and compound, and want of union is so rare an occurrence that he does not recollect more than six or eight instances of it. According to Lonsdale, (*On Fractures*, p. 89,) not more than five or six cases of false joint (except those within a capsule) have occurred out of nearly four thousand fractures treated at the Middlesex Hospital; and Sir Stephen Hammick, (*Practical Remarks on Amputations, Fractures, &c.* p. 122, 1830,) whose experience at the Plymouth Hospital was extensive, asserts, that he never discharged from that institution more than three patients with the bones not united. Of the great number of fractures that must have fallen under the notice of Mr. Liston, (*Lancet*, ii, p. 168, 1835-6,) it happened but in one instance that the bones did not unite. Out of a very carefully prepared table of 367 cases of fracture furnished by Dr. Peirson, (*Remarks on Fractures*, Boston, 1840,) but a single one is stated to have terminated in artificial joint; and by an Edinburgh writer it is affirmed that cases of non-union are so unfrequent, that it is regarded in that city as a curiosity almost to see them. In Philadelphia they are of rare occurrence; at the Pennsylvania Hospital, where between the years 1830 and 1840, nine hundred and forty-six cases of recent fracture were received, no instance of non-union followed the treatment pursued; all the cases observed there during that time, (thirteen in number,) having been sent to the institution from distant parts. (*Am. Journ. of Med. Sci.* No. 2, N.S. 1841.) The only writer known to me who holds an opinion contrary to that here advanced, is Mr. Amesbury; he asserts, (*Observations on Fractures of long*

standing, p. 195, London, 1829,) that fractures of long standing "are by no means uncommon," and furnishes his personal experience in fifty-six cases of this kind,—a number much greater than any one surgeon has ever before had an opportunity of witnessing. We are at a loss to account for its frequency in his practice, but a reviewer of his own nation observes of his statement, that the surgery of fractures must be singularly bad, where one individual has had occasion to number fifty-six examples of non-union, even making allowance for the fact, that all the bad cases came to Mr. A. alone. (*Edin. Med. and Surg. Journ.* xxxi, 1829.) Setting aside however the positive knowledge arrived at by an appeal to figures, we think it evident that the generality of surgeons do not find it of very common occurrence, from the little attention that has been bestowed upon the affection, and the comparatively few cases to be found reported in our journals.

To understand well the mechanism of false or artificial joints, and judge of the proper adaptation of the different methods recommended for their cure, a correct knowledge of the changes that take place in the natural process of reparation of fractured bones is requisite, and we shall preface our remarks on the immediate subject of this paper, by a concise account of the formation of callus.

By the ancients, the union of bones after fracture was attributed to the exudation of a viscous fluid from their surfaces, called the osseous juice, which gradually acquired consistence, and joined firmly together the ends of the broken bone, in the same manner as glue would unite two pieces of wood. This theory of the mode of union continued to be taught till towards the middle of the 18th century, when it was overthrown by the experiments of Duhamel. Comparing the periosteum to the bark of trees, Duhamel held that the callus was produced by the elongation and swelling of this membrane, either alone, or together with that lining the medullary canal, uniting themselves to the same parts in the opposite fragments. He then supposed that ossification occurred, from which resulted the formation of two bands or supports, one internal, and the other external, placed between the different membranes and the fragments to which they adhered, and extending from one to the other, in such a way as to maintain them closely in contact. In conjunction with his pupil Dethleef, Haller performed a number of experiments on the formation of callus, the result of which was an opinion contrary to that advanced by Duhamel. He totally discards the idea that the periosteum in any way contributed to the re-establishment of the continuity of the broken bone, and believed the callus to be a jelly-like fluid produced by the fractured surface of the bones, and of the marrow, which gradually became organized and passed through a cartilaginous to a bony state. John Hunter considered the formation of callus as due to the organization of the blood effused around the seat of fracture, and its consequent conversion into cartilage and bone. The ideas of Hunter relative to the formation of callus, have in our own time been in great part adopted by

Mr. Howship. The opinion arrived at by this gentleman after the performance of a number of experiments, is, that the blood effused immediately after the occurrence of a fracture, becomes the medium in which the ossific process is first established. According to him, the periosteum assumes by degrees the characters of cartilage, and the bony matter is deposited successively upon the surfaces of the fractured fragments, the circumference of their extremities, and within the medullary cavity. Later investigations of the French physiologists and surgeons have however clearly shown, that the process of union is not exactly effected in any of these ways, and their views, which are founded upon numerous experiments upon the inferior animals, as well as upon autopsic examinations in all stages of fracture, are those now generally adopted. According to the French, two distinct epochs may be distinguished in the formation of callus, or rather there are two calluses successively formed. The first, termed the "provisional callus," is produced ordinarily in the space of thirty or forty days by the reunion and ossification of the periosteum, the cellular texture, sometimes of the neighbouring muscles, and in the long bones, by the ossification of the medullary tissue. The second, called "definitive callus," is formed by the immediate agglutination of the two broken ends themselves, and is never completely finished before eight months or a year, by which time the provisional callus, that is gradually absorbed, has disappeared.

The provisional callus surrounding the fractured fragments, though in larger quantity, is of a less solid nature than that which is definitively formed. The definitive callus when complete, though less voluminous, offers so great a resistance that the bone may be fractured more easily at any other point than that at which it was previously injured.

The progress of consolidation after fractures may be divided into five periods, each characterized by distinct phenomena. (*Breschet, Récherches sur la Formation du Cal.* Paris, 1819.)

The first period extends from the time of fracture to the 8th or 10th day, and presents the following appearances. The blood poured out by the ruptured vessels of the bone, periosteum, medullary membrane, medulla, and the surrounding cellular tissue, coagulates in all the surrounding parts, as well as in the medullary canal. Slight inflammation then follows, the cellular tissue, and the parts adjacent, becoming infiltrated with a gelatinous lymph. In the interior of the bone, the medulla and its membrane likewise become inflamed, and pour out the same substance around and between the broken surfaces, and this effusion produces some thickening about the fracture, which in consequence becomes less movable. The extravasated blood is in a short time altogether, or in part absorbed: it in no case contributes to the reunion of the fracture, and when in large quantity, rather retards the process. By the end of the period mentioned, (10th day,) the ends of the fractured bone are surrounded either by a viscid substance, or by a homogeneous tissue of a reddish colour and spongy consistence, produced by the general engorgement and infiltration of the soft parts.

The second period extends from the 10th day to the 20th or 25th. During this time the swelling of the soft parts diminishes in size, and the different tissues assume their natural appearances. Gradually the muscles, tendons, and other parts, are disengaged from the general thickening by which they were surrounded, and there remains only a tumour, separated from all the neighbouring parts, even from the tendons, for which grooves, or complete channels, are furnished, in which they move with more or less facility. This tumour is termed the "callous tumour;" it is thicker at the point of fracture than elsewhere, and diminishes gradually in size from this point to its extremities; it is of a whitish colour, and has the firmness and consistence of fibro-cartilage, with the fibres running parallel to the axis of the bone. The part of this tumour adherent to the bone is formed by the periosteum with which its substance is blended, and it is more adherent to the bone, the nearer we approach the fracture, at which part it becomes difficult to separate it. Towards the extremity of the callous tumour, the periosteum becomes again distinct and easily separable from the bone. The medullary canal is sometimes obliterated at the point of injury, or even for some distance above and below it, in consequence of its membrane becoming thickened; the matter poured out within it, passes rapidly to a state of cartilage. During this second period the work of restoration is principally external, the lymph by which the ends of the bone are glued together (within the callus) undergoing but little change. Even at the end of this period, the fracture still admits of motion, though no crepitus or grating can be produced.

The third period extends from the 20th or 25th day, to the 30th, 40th, 50th or 60th, according to the age, and state of general health of the patient. During this time ossification proceeds, and the external swelling, or provisional callus, becomes entirely ossified, so as to form a firm bony clasp. The periosteum is thicker than in the natural state, becomes apparent upon the tumour, and is continued both above and below with that of the fragments. The muscles and tendons have by this time become free from the tumour, though they do not admit of much motion on account of the rigidity of the cellular tissue. At the end of this period, in the case of a thigh, or leg, the fractured limb has sufficient strength to permit of its being used, though if the callus at this time be divided, it will be found that the extremities of the bones move readily upon each other, the substance existing between the fragments being as yet soft and vascular.

The fourth period extends from the 50th or 60th day, to the end of the 5th or 6th month. During this period the ossified callus becomes closer and more compact. The soft substance joining together the ends of the bone gradually ossifies, and the fractured extremities, which hitherto have not been united, are now found to be connected by a layer of newly formed and compact bone. This is termed the definitive callus, and in proportion to its formation is the provisional callus diminished.

The fifth period extends from the 5th or 6th, to the 8th, 10th or 12th month. In this period, the external provisional callus having served the purpose of keeping the ends of the bone in contact for a certain time, is entirely absorbed, while that portion of it formed by the medullary effusion, is also absorbed, and the medullary membrane returns to its natural state. The periosteum assumes its normal thickness and texture, the cellular tissue its elasticity, and the muscles, and tendons, regain their free motion. Finally, the definitive callus is wrought into cells and canals, by which the continuity of the medullary cavity of the bone is restored, and the work of consolidation is terminated.

Such are the phenomena which accompany the formation of callus in ordinary cases, where the fractured fragments have been placed in a good position; but sometimes it happens that fractures are badly set, that is, that the ends of the broken bone instead of being placed in apposition, touch only at a single point, and nevertheless the bone becomes united. In these cases, the definitive callus never takes place, but the fragments are held together by the provisional deposit, which becomes permanent, and forms a firm bond of union. When fracture is complicated with a wound and suppuration follows, after a lapse of time, ordinarily of several months duration, during which splinters of bone, if there be any, are thrown off, the extremities of the fragments become softened and covered with vascular granulations, and unite together in a mode analogous to that of suppurating wounds of the soft parts, and it is this cicatrix, which, by a deposite of bony matter in it, constitutes the callus.

From what has been stated in regard to the formation of callus, it appears,

1. That when a fractured cylindrical bone unites, a broad band or support, acting like a circular splint, and termed provisional callus, is first deposited around the seat of injury, by which the extremities are brought together and fixed.
2. That the permanent callus is formed between the ends of the bone only, and unites firmly, and closely, the fractured surfaces.
3. That when the permanent callus is produced, that first deposited, having fulfilled its transient purposes, is entirely absorbed.
4. That at the period at which splints are usually laid aside, and the union is looked upon as firm, the deposit of the permanent callus is scarcely begun, the firmness in the broken part depending solely upon the temporary deposite.

With a knowledge of these facts we are enabled to explain phenomena sometimes observed after fractures, which by any of the other theories are altogether inexplicable; the renewal of the deformity after the removal of splints, at the end of a period that experience shows generally to be sufficient for a cure, the possibility of remedying by a proper and well directed treatment, limbs that are deformed, and why this possibility exists only during a certain time, and then ceases, are readily explained by it. They are

fruitful too in practical hints relative to precautions that should be taken during the convalescence of fractures, particularly when oblique, as well as in regard to the length of time that in certain cases, it is necessary to prolong the application of an apparatus, and point out the probability of rupturing advantageously within a certain period, the callus of badly set bones.

Perfect osseous union however, is sometimes not effected between the extremities of a fractured bone, and we propose now to investigate the appearances presented by the parts where this failure exists.

Authorities differ as to the state in which the bones are found upon dissection in ununited fractures, though generally, the opinion maintained by Boyer, that a true joint, with a well marked capsular ligament containing a fluid resembling synovia, is never formed, has been adopted. That in the majority of instances this opinion may be correct, we are willing to acknowledge, though an examination of such post-mortem examples as we have found recorded, as well as instances that we have ourselves observed, show that it is by no means uniformly the case. The mode of union between the fractured extremities in these cases may be described as of four kinds.

In the first, the bones are united together, and are in every respect properly surrounded by the cartilaginous mass, which has been described under the name of the callous tumour, the formation of which has gone on regularly, but in consequence of some retardation in the process, bony matter is not deposited, and as a consequence, it wants solidity, the part continuing easily movable. It is in this state that the bones are found in what are termed, delayed consolidations, and it is to this class of cases, as we shall hereafter see, that the treatment by rest and compression, is peculiarly suited. The rough handling of a limb in this state is always accompanied with some pain, a circumstance of much importance in its diagnosis.

In the second class of cases, there is entire want of union of any sort between the fragments, the ends of which seem to be diminished in size, and are extremely movable beneath the integuments. The limb in these cases is found greatly shrunken, and hangs perfectly useless.

In the third, and most common class of cases, the medullary canal is obliterated in both fragments, and the ends of the bone are found more or less absorbed and rounded, or are pointed and covered by a tissue resembling the periosteum, and are connected together by strong ligamentous, or fibro-ligamentous bands, passing from the extremity of one fractured fragment to that of the other. Sometimes this bond of union is constituted by a single ligament, while in other instances it is made up of several narrow bands having separate attachments: in either case the newly formed substance is firmly adherent to the bones, and if of any length, is in a high degree pliable.

In the fourth class of cases, a dense capsule without opening of any sort, containing a fluid similar to synovia, and resembling closely the complete

capsular ligaments, is found. In these cases, the points of the bony fragments corresponding to each other, are rounded, smooth and polished, in some instances are eburnated, and in others, are covered with points, or even thin plates of cartilage, and a membrane closely resembling the synovial of the natural articulations. It is in this kind of cases that the member affected may still be of some utility to the patient, the fragments being so firmly held together as to be displaced only upon the application of considerable force. Boyer, (*Maladies Chirurgicales*, iii, p. 103, Paris, 1831,) Hewson, (*North American Med. and Surg. Journ.* No. 9, p. 7, 1828,) Chelius, (*Traité de Chirurgie*, Trad. par Pigné, p. 150, Bruxelles, 1836,) and other writers, have doubted the existence of these newly formed joints; but the observations of Sylvestre, (*Nouvelles de la République des Lettres of Bayle*, p. 718, July, 1685,) of Brodie, (*London Medical Gazette*, xiii, p. 57, 1833,) of Beclard, (*General Anatomy*, Trans. by Hayward, pp. 149, 248,) Home, (*Trans. of Med. Chir. Soc. of Edinburgh*, i, p. 233, 1793,) Howship, (*Med. Chir. Transactions*, viii, p. 517, 1817,) Otto, (*Pathological Anatomy*, Trans. by South, i, p. 138,) Kuhnholz, (*Journal Complementaire*, iii, p. 291,) Houston, (*Dublin Medical Journal*, viii, p. 493,) Key, (Cooper on *Fractures and Dislocations*, 4th ed. p. 508, London, 1824,) and Langenbeck, all show that such are occasionally found. In nine false articulations which he produced in a series of experiments upon dogs, M. Breschet, (*Loc. Cit.* p. 34,) observed six in which the extremities of the bones were rounded, and cartilages, synovial membranes, and all the other appearances constituting a true joint formed, while in three only, were the bones connected by means of a ligamentous matter passing from one extremity to the other.

Besides the interest which must attach to a correct knowledge of the pathological anatomy of an affection, the fact of true joints being often formed as a consequence of solution of continuity in a bone, is important from its bearing upon a point of surgical therapeutics. The operation devised by Dr. J. R. Barton for the cure of ankylosis of the hip joint, is in part based upon a knowledge of the occurrence of this state of ununited fractures, and although the joint which succeeds the division of a bone may never permit of motions as extensive, or be as firm as original structure, on account of the less solidity of the capsules surrounding it, the smaller surfaces presented to each other, and the difficulty which the muscles experience in accommodating themselves to the new joint; still, the operation is based upon sound observation, was justified by the event, and is one that under similar circumstances, is in every way worthy of imitation.

When the fractured fragments have been for a long time disunited, the structure of the bones themselves undergo a change, and become very light, being deprived of their reticulated spongy substance, and reduced to a mere shell of compact structure.

The causes of non-union after fracture are either constitutional or local.

Among the constitutional causes, the existence of *syphilis* in the system is generally looked upon as being sufficient to retard, or altogether prevent, the process of union after fractures. Numerous instances in which this has been the apparent cause, might be cited from the old writers. Among the moderns, M. Sanson is one of those who lays most stress upon it. "I have twice," says he, "had occasion to observe the marked influence of syphilis in retarding consolidation. One of the cases was a fracture of the leg, which was not firm after eight months employment of the ordinary means of treatment. The other was a fracture of the humerus, which was not united after eighteen months, except by a soft and flexible substance. In both these cases, unequivocal proofs existed of concomitant syphilitic affections, and after an anti-syphilitic treatment of two months was employed, consolidation took place." (*Dictionnaire de Med. and Chir. Prat.* iii, p. 492.) Berard (*Des causes qui empêchent ou retardent la consolidation des Fractures et des moyens de l'obtenir.—Thèse*, Paris, 1833) mentions the case of a simple fracture of the leg, observed by M. Nicod, in which there was no union after nine months of treatment, when syphilitic symptoms being discovered, the patient was placed under a mercurial course, and consolidation took place. An instance was related to the Academy of Medicine of Paris, by M. Beulac, (*Journ. de Med. Chir. and Pharm.* in 40 vols. tom. xxv, p. 216,) of a fracture that had existed two months, where the consolidation was retarded by syphilis, under which the patient laboured, and at the same sitting several members stated like facts. The following case, in which want of union seemed owing to the existence of syphilis, has been obligingly communicated to me by Dr. Condie. On the 28th of August, 1828, J. Rowen, æt. 48, fractured both bones of the left forearm, some inches above the wrist, by a fall from a hay loft. A few hours subsequent to the accident the bones were properly reduced, and the arm put in splints. He was a man of dissipated habits, and had been since his 21st year repeatedly under treatment in hospitals for syphilis. At the time of his accident, he was labouring under ulceration of the throat, nodes and cutaneous blotches, and his gums and breath exhibited indications of mercurial action. The Lisbon diet drink and a nourishing diet were ordered, in addition to exercise in the open air. On the 30th of September, no attempt at union having taken place, Dr. Physick saw the patient, but suggested no change in the treatment. On the 22d of November, eighty-five days after the occurrence of the accident, when the patient was last seen, no union was perceptible. Opposed to these statements, however, the great experience of M. Lagneau, (*Exposé des Symp. de la Mal. Vénérienne*, p. 525, Paris 1818,) may be quoted, who mentions that he has witnessed numerous examples of fractures, in which union took place promptly, notwithstanding the existence of constitutional syphilis. Oppenheim, (*On False Joints, in Zeitschrift fur die Gesammte Medicin*, No. 5, May 1837,) too, avers, that he has observed various cases, in which general syphilis being present, fractures united exceedingly well, and is inclined totally to discard the suspicion that syphilis in any way retards the

union of broken bones. M. Berard, after numerous researches, sums up his opinion in the following language (*Op. citat.* p. 11): "Despite the numerous occasions in which surgeons have witnessed the co-existence of syphilis with fractures, it has been very rarely proved that the syphilitic virus exercises any influence upon the formation of callus."

*Pregnancy* and *suckling*, are stated in most of our treatises also at times to retard, or prevent, firm union from taking place after fracture.

As a general rule it may be said that these states do not interfere with the occurrence of bony union. Of fifty-six cases examined by Mr. Amesbury, (*On Fractures*, 2d ed. p. 197, 1829,) but two happened during the process of gestation, and these he is not disposed to attribute to the peculiar disturbance of the system which is observed in pregnancy. Callisen (*Syst. Chir. Hodiern.* Pars 1, § 1313) reports that he has in several cases seen fractures in pregnant women get perfectly well, though the time required for firm union, was a little longer than that ordinarily demanded. Of four cases of fracture which came under the care of Mr. Latta, in the 5th, 6th and 7th months of pregnancy, (two of the thigh, one of the tibia, and one of the forearm,) all were cured in the ordinary time. (*System of Surgery*, iii, p. 363.) Mr. Liston (*Elements of Surgery*, 2d ed. 1839, p. 686) has often seen fractures in women carrying children unite as speedily and firmly as if the patients had not been in that state, and otherwise in robust health; but observes, "profuse uterine or vaginal discharges, or determination to particular parts, or organs, will certainly retard union." Several of my friends who have observed fractures in this class of patients, have assured me that the injuries have been repaired in the usual period. That however these states do occasionally retard the reparation of fractured bones, there can be no doubt. Werner (*Richter*, quoted from *Cooper's Dict.* p. 546, ed. 1838) has published the case of a fractured radius in a pregnant woman, where the cure was apparently retarded for a long time by this circumstance, and though the union took place previously to delivery, the callus was not very firm till after that event. Fabricius Hildanus, (*Opera.* 1681, *Cent.* 5, *Obs.* 87, and *Cent.* 6, *Obs.* 68,) Wilson, (*On the Human Skeleton*, p. 214,) Ferdinand Hertodius, (*Ephem. des Cur. de la Nat.* 1re année obs. 25, quoted from *Bib. Choisie de Med.* xxiv, p. 595,) have all witnessed cases in which this retardation had taken place. A remarkable and well detailed instance of this kind is recorded by Mr. Alanson, (*Med. Obs. and Inquiries*, iv, 1772.) It is that of a delicate female, who in the second month of pregnancy met with an oblique fracture of the tibia, which in spite of a well directed treatment had not united when she was delivered at full time (seven months after the accident), but which as she recovered strength after her confinement began to unite, and nine weeks after this period was able to walk about her room with a firm limb. What proves beyond a doubt in this case that the want of union was owing entirely to her pregnant state was, that three months before impregnation she had been very happily and speedily cured of a fractured femur.

Another well described case, in which a fracture received during pregnancy did not unite till after delivery, was observed by Dr. Bard of New York, and is to be found in the Philosophical Transactions, (xlvi, p. 397, 1750.) In this instance the left fore-arm was fractured obliquely in the third month of pregnancy; finding the arm continued flexible at the end of seventy-five days, though the ends of the bones were in perfect apposition, Dr. B. applied an apparatus to keep the limb in a good position, and gave encouraging hopes to the patient that after her labour, the economy of nature would be more immediately directed to the recovery of the use of her arm. In less than a month after her delivery, the callus was fully formed, and the patient recovered the use of her arm. The following case, kindly furnished to me by Dr. Condie of this city, also strikingly shows the influence that may be exerted by a state of pregnancy upon the consolidation of fractures. S. R. æt. 36, on the 13th of October 1820, being then in the eighth month of her third pregnancy, fell in going up stairs and fractured her right humerus immediately below the insertion of the deltoid muscle. The fractured bone was carefully adjusted within half an hour after the accident, and the patient being to all appearance in perfect health, a speedy union was anticipated. No union occurring, Dr. Physick saw the patient on the 13th of November, and carefully examined her arm. He remarked, that according to his experience, fractures occurring in pregnant females often remained ununited until after parturition, when union very generally and rapidly took place, and believed this would be the case with S. R. provided motion at the seat of injury was guarded against.

On the 27th of November, the patient was delivered of a healthy child, rather above the common size, and by the 31st of December, the bone had become firmly united.

Whether the states of pregnancy, or of suckling, have any direct effect in preventing union of the bones, or whether this is only in consequence of the debility which these conditions of system often induce, is undetermined. I am myself inclined to adopt the latter supposition, and in support of it will adduce the cases reported by Sir Stephen Love Hammick. "I have seen," observes this author, (*Practical Remarks on Amputations, Fractures, &c.* p. 121,) "three cases of this sort, one of the leg, in a woman in the first months, who was extremely debilitated from an incessant irritability of stomach, causing her to reject all her food, but as the pregnancy advanced her stomach became tranquil, when on recovering her strength the bone united. Another had a fracture of the humerus in the latter months; the patient was in a state of great exhaustion; after her delivery she would persist in nursing the child, which continued her weakness, and it was not till two months after she consented to wean it that the bone united by the vigour of the system having returned. The third was in the last months of pregnancy, and after delivery, not attempting to nurse the infant, she rapidly improved in health, and the limb quickly got well."

*Cancer* has been placed among the causes which hinder the consolidation of fractured bones, though perhaps by the generality of authors it is denied to exert any influence over the process. "Women labouring under cancer," says Sir B. Brodie, (*Lond. Med. Gaz.* xiii, p. 56, 1833,) "are liable to a similar disease of different bones of the body, which then become brittle and very liable to break. I saw an old woman dying of this disease who in turning in bed broke the femur; union took place here as well as under ordinary circumstances. I attended a lady who had cancer of the breast, and a scirrhouss affection of the collar bone, and one day in moving her arm, the collar bone was broken, but it united just as if it had been a healthy bone." Mr. Liston, (*Practical Surgery*, 2d American edition, p. 100,) has recorded the case of a female,  $\text{wt. } 49$ , affected with carcinomatous tumours under the jaw and in both breasts, as well as in the uterus, and other internal organs, in whom firm union occurred after two fractures of the left, and one of the right humerus, all received within fourteen months, and produced by very slight causes. Mr. Coates, and Sir Charles Bell, (*Lond. Med. Gaz.* xiii,) have given, each a case, of fracture occurring in cancerous patients, where no sort of union had formed after eight and six weeks, and where cancerous matter was found deposited in the bones. On this point, my own experience permits me to say nothing, but after a very careful examination of what has been written upon the subject, I believe it may be stated, that where the fracture arises in consequence of a true cancerous deposit around, or in the interior of the bones, and producing absorption of their tissue, that no union takes place, but where, as is usually the case, it is owing to a mere brittleness of the bones occasioned by what has been denominated by Mr. Curling, eccentric atrophy, fractures though occurring from very slight causes, will unite readily.

*Fragility of the bones.* The same cause which gives rise to undue fragility in the bony structure, might *a priori* be supposed to retard, if it did not altogether prevent their consolidation after fractures. Experience however proves this not to be the case, and generally indeed, it may be said, that where a proneness to fracture from trifling causes exists, these accidents are repaired with great facility. Dr. Good (*Study of Medicine*, v, p. 332, 3d ed.) mentions the instance of a lady  $\text{wt. } 72$ , who broke both femurs by merely kneeling down at church, and who had the humerus also broken in the efforts made to remove her, without any violence, and with little pain. Scarcely any constitutional disturbance followed, and the bones united in a few weeks. Professor Gibson, (*Institutes and Practice of Surgery*, i, p. 233, 1838,) speaks of the case of a young man who in a period of twenty-three years experienced twenty-four fractures. From infancy he had been subject to fractures from the slightest causes, and his limbs had all been repeatedly broken, even from so trivial an accident as catching the foot in a fold of carpet whilst walking across the room. The clavicles had been fractured eight times. The boy always enjoyed excellent health, and the

bones united without difficulty or much deformity. The same author furnishes four other cases, observed by different gentlemen in our country, in all of which fragility existed in remarkable degrees. In the cabinet of M. Esquirol (*Dictionnaire de Médecine*, xiii, p. 407, 2d ed.) the skeleton of a rachitic woman is to be seen, in which exists traces of upwards of two hundred fractures, all more or less firmly consolidated.

*Scurvy, fevers of a low type*, or any other disease inducing great debility, or actual prostration, may also prevent the reparative process after fractures from taking place as in ordinary cases.

The cause of want of union is sometimes to be found in the *general impoverished and bad state of the system*, produced by improper abstinence from food, or the withdrawal of an habitual stimulus. The following cases illustrative of this cause are given by Sir B. Brodie. (*Lond. Med. Gaz.* xiii, p. 56, 1833.) "A gentleman was growing fat, and not liking to do so, he placed himself on a very slim diet, though accustomed to good living previously. After six months of starvation, he broke his arm, and the bone would not unite. I saw him many months afterwards, and there was scarcely any union, even by soft substance. Another patient about whom I was consulted, a lady, was growing fat, and thought she would also prevent it, by pursuing a similar system of diet. Some months afterwards she broke her arm and union did not take place." A striking instance of the same cause in preventing union is related by M. Noel, (*Prix de l'Acad. de Chirurg.* v, p. 45, 8vo, Paris, 1819,) of a girl, æstat. 18, of good constitution, in whom no attempt at union had taken place after a fracture of the leg at its middle part, at the end of eight months. The patient was greatly reduced from want of nourishment, she having subsisted for some time upon six ounces of bread, with water, per diem. Supposing want of union to depend upon insufficient nourishment, the patient was placed upon a good diet, and about six weeks afterwards union of the fractured bones was perfect. Beckett relates the case of a patient, æstat. 23, with fractured os humeri, in whom the loss of a large quantity of blood, and the denying him a competent sustenance prevented re-union till the end of nine months. (*Chirurgical Observations*, p. 16.) A case in which want of union may perhaps be attributed to slim diet together with repeated bleedings, is given by Dr. Hewson. (*North American Journ. for Jan. 1828*, p. 11.) This patient was admitted into the Pennsylvania Hospital in March 1827, on account of an imperfect union of the tibia near its centre. In August 1818, both bones of the leg were broken. He was subjected to a severe antiphlogistic treatment and lost several pounds of blood. It was not until six weeks after the accident that he was allowed any portion of animal food. Other striking illustrations of the effect of an altered mode of living, may be found in the *Medico-Chirurgical Review* for January 1836.

The influence of a low diet, long continued, upon the parts interested in

compound fractures, must have been noticed by all surgeons, and the good effect produced in such cases by an increased diet, and the allowance of an accustomed stimulus, as well in causing the more rapid deposit of callus, as in improving the state of the wound, have been observed. That the large abstraction of blood alone will not prevent the formation of callus is well seen in the following cases.

Isaac Yorke, ætat. 19, was admitted into the Pennsylvania Hospital, October 5th, 1801, for fracture of the right thigh. His accident had happened one week previously to his admission, during which time he had been delirious, and had undergone five bleedings, in all amounting to one hundred and two ounces. He continued to do well until the 7th, when his delirium returned, and between this date and the 15th, he was bled at different times to the amount of ninety ounces, making in all one hundred and ninety-two ounces; from the 15th he recovered rapidly, and was discharged from the hospital January 13th, 1802.

Jas. Orr, ætat. 32, was admitted May 16th, 1804, for compound fracture of the leg two inches above the ankle, and injury of his thorax. Great pain and difficulty of breathing followed the accident, to relieve which he lost thirty ounces of blood in the first twenty-four hours following it. On the 20th, delirium set in, and in the two following days sixty-two ounces more of blood were taken from him, making in all ninety ounces; after this his symptoms abated, and he recovered rapidly. (*Penn. Hosp. Case Book*, i, pp. 27, 31.)

The influence of the nervous system over the processes of reparation in the body is well known, and that *want of nervous influence* might alone be sufficient to prevent consolidation after fracture from occurring, have been supposed. That it may be a sufficient cause there can be no doubt; an instance is mentioned by Mr. Travers, (*Further Inquiry, &c.* p. 436,) in which union failed to proceed after a fracture of the leg that was paralysed from fracture of the lumbar vertebrae, although the humerus, broken at the same time, united perfectly in the usual period. Mr. Tuson notices a case of paralysis of the lower part of the body from injury of the spine, accompanied by fracture of the fibula and dislocation of the shoulder joint, in which the fracture of the fibula, the leg being paralysed, did not reunite, nor did there appear any reaction about the parts to effect it; whilst the capsular ligament of the shoulder joint, which was not paralysed, did unite and was scarcely perceptible. (*On the Spine*, p. 254.) Mr. Benjamin Phillips (*Lond. Med. Gaz.* for May 1840, p. 327) has seen a case in which the same injury that fractured a man's leg injured the lower part of the spine; he lived five weeks, but there had been no effort at reparation. Diminished nervous influence will not, however, in all instances, hinder the formation of callus, as is shown by a case recorded by Mr. Busk, (*Lond. Med. Gaz.* for April 1840, p. 97,) of a gentleman, ætat. 65, who had been more or less paralytic for upwards of twenty years, for the last twelve or fourteen of

which he had been completely deprived of all power of motion and sensation from the loins downwards, who fractured his left leg below the middle; and in whom at the end of five weeks the bones had firmly united.

*Cutting off the direct supply of blood* to an extremity by ligature of the principal arterial trunk, might *a priori* be supposed sufficient to retard union after fracture. This however does not seem always to exert a marked influence upon the process. Petit (*Mal. des Os*, quoted from the thesis of Bérard, p. 27) mentions a fractured leg accompanied by rupture of the anterior tibial artery, in which union was effected in the usual way. In the Surgical Essays of Mr. B. Cooper, is a case of fractured femur accompanied with injury to the popliteal artery, where, although the femoral was taken up, the fracture was soundly united in six weeks. In a case, however, of a similar kind, reported by Dupuytren, (*Leçons Orales*, iv, 618,) the work of consolidation went on slowly, the nutrition being weakened in the limb by the ligature of the artery. At the end of the first month, the callus had scarcely begun to be formed; at the termination of the second, union was very weak, and it did not become perfectly solid till after the expiration of four months. In animals, such as guinea pigs, rabbits, &c. Brodie has found by experiment, that the reparative process in a fracture of the thigh bone is delayed in its commencement for a week or a fortnight, by placing a ligature on the femoral artery, but at the end of that time union goes on as though no such operation had been done. (*Lancet*, i, p. 381, 1840-1.)

Bérard (*Archives Générales*, xxxvii, p. 176, 1835) has shown that the period at which the epiphyses are joined to the diaphyses of the long bones, depends upon the direction of the nutritive artery—for example, it is found that in the humerus, where the direction of this vessel is from above downwards, consolidation takes place soonest at its inferior extremity. In the fore-arm, the course of the nutrient vessel is from below upwards, and here consolidation of the epiphyses is found to occur at the elbow sooner than at the wrist. In the inferior members, on the contrary, the epiphyses composing the knee are the last which become firm, because in the femur the nutritious artery runs upwards, and in the bones of the leg, it courses from above downwards. Aware of these facts, M. Guèretin (*Presse Médicale*, i, p. 45) was led to examine into the influence which the direction of the nutritious arteries exerted upon the consolidation of fractures, and has ascertained that ununited fractures are most common in the points opposite to the direction of the nutritive vessel. The following analysis of 35 cases, to show the relation between the seat of ununited fractures and the nutritious vessels, copied from his paper, possesses much interest.

Bones Affected.	No. of Cases.	Seat of Fracture.
Humerus	9	Above the entrance of the nutrient artery (upper half of bone).
Do.	4	Below the entrance of the nutrient artery (lower half of bone).

Fore-Arm	1	Above the entrance of the nutrient vessels of the two bones (superior third).
Do.	7	Below the entrance of the nutrient vessels of the two bones (lower half).
Femur	3	Above the entrance of the nutrient vessel (superior half).
Do.	5	Below the entrance of the nutrient vessel (lower half).
Leg	4	Above the entrance of the nutrient vessels of the two bones (superior third).
Do.	2	Below the entrance of the nutrient vessels of the two bones (lower half).

As the seat of the entrance of the vessel varies, though but little, and very rarely, cases of non-consolidation have been taken for this table which are distant at least one inch from the point usually assigned for its entrance.

In addition to the researches of M. Guèretin, it has been shown by Mr. Curling, (*Med. Chir. Trans.* xx,) that in fractures of the long bones, the portion below the entrance of the nutrient artery becomes gradually atrophied, being supplied only by the periosteal branches. Thus, in femurs fractured below the entrance of this vessel, the inferior cavity of the lower extremity becomes enlarged, the cancelli expanded, and the walls thinned. A like alteration is observed in fractured tibia, whilst in a humerus, broken near the middle and somewhat above the entrance of the nutrient artery, the upper portion was the seat of change. My own researches on this point do not, however, confirm those of M. Guèretin. An analysis of 41 cases in which I find the exact point of fracture indicated, gives the following result.

Bones Affected.	No. of Cases.	Seat of Fracture.
Humerus	4	Above the entrance of the nutrient artery (upper half of bone).
Do.	9	Below the entrance of the nutrient artery (lower half of bone).
Fore-Arm	1	Above the entrance of the nutrient vessels of the two bones (superior third).
Do.	3	Below the entrance of the nutrient vessels of the two bones (lower half).
Femur	7	Above the entrance of the nutrient vessel (upper half).
Do.	6	Below the entrance of the nutrient vessel (lower half).
Leg	1	Above the entrance of the nutrient vessels of the two bones (superior third).
Do.	10	Below the entrance of the nutrient vessels of the two bones (lower half).

*Advanced age* is placed among the causes which always retard the consolidation of fractured bones, though the reading of observations reported, and daily experience, does not confirm it. In some cases of this kind, I have seen the callus deposited and firm union occur remarkably soon. In 1838,

two instances in which this took place were treated by me at the Pennsylvania Hospital. In one of them, occurring in a man aged ninety, the humerus was fractured near its middle, and under the usual treatment, firm union took place at the end of six weeks. In the other, a decrepid female, aged eighty, who died from exhaustion eighty-four days after fractures of the middle of the femur, and the ilium, the mass of matter thrown out around the fractured portions was truly astonishing. An instance is mentioned by Professor Horner, (*Treatise on Anatomy*, i, p. 27,) in which a simple fracture of the os humeri occurring in a female, aged ninety, was firmly united at the end of five weeks. Adverting to the supposed influence of old age in causing imperfection or failure of bony union, Dr. Wright thus gives his experience. "I have been frequently struck with the resources of the system in old age, as displayed in the prompt and perfect repair of injuries both of the soft and solid parts of the body. In the closing of wounds, the filling up and healing of extensive ulcers, and the firm reunion of fractures, it has occurred to me to observe all those processes accomplished with a facility and completeness scarcely exceeded at any age, in some instances where the subjects of such accidents had passed the eightieth year of life. (*American Journ. of Med. Sci.* iv, p. 273). Bonn, (*Descript. thesauri ossium morb.* p. 59, 61, 1783, quoted from *Bérard's thesis*, p. 7,) however, has furnished two observations, where advanced age appeared to be the only circumstance which retarded the formation of callus. Some idea of the influence of age in the production of false joint, may be derived from an analysis of 112 cases extracted from our table, in which the age is noted.

Of the age of 20 and under there were	14
Between the ages of 20 and 30 there were	53
Between the ages of 30 and 40 " "	21
Above the age of 40 " "	24
<hr/>	
112	

According to Larrey, (*Memoirs of Military Surgery*, trans. by Hall, i, p. 301,) even the season and atmospheric temperature may exert some influence upon the consolidation of fractured bones; he relates that the gunshot wounds of the superior extremities complicated with fracture, especially those of the humerus, received by the French soldiers in Syria, although dressed according to art, were almost all followed by accidental articulations which he attributes to the following causes.

1st. To the continual motion to which the wounded were exposed after their departure from Syria, until their arrival in Egypt, and being obliged to travel mounted or on foot.

2d. To the bad quality of their food, and to the brackish water that they were forced to drink on this tedious journey.

3d. To the state of the atmosphere in Syria, that is almost deprived of vital air, and loaded with pernicious vapours arising from the numerous marshes near which they remained a long time.

The local causes which may hinder the consolidation of fractured bones, are various.

1st. *Frequent motion of the part.* This may be owing either to indocility and perverseness on the part of the patient, to removing patients from place to place after these accidents, or to a want of a proper apparatus wherein to confine the fractured limb. Too much motion from injudicious management of the fracture by frequent dressing, or the laying aside of splints, and the use of the limb at too early a period after the accident, may also give rise to it. Frequent motion of a fractured limb is the only cause of want of union mentioned by Celsus. Mr. Amesbury (*Loc. citat.* p. 197) considers want of rest to be more frequently the occasion of deficient union than any other, and considers it to have been the primary cause in almost all the cases which he had examined. The opinion that want of union is to be attributed most generally to some defect in our treatment, is held by Dr. J. R. Barton, (*Medical Recorder*, ix, p. 276, 1826,) Liston, (*Lancet*, ii, p. 168, 1835-6,) Key, (*Lond. Med. Gaz.* iv, p. 262, 1829,) Macfarlane, (*Edin. Med. and Surg. Journ.* xlvii, 1837,) and most other surgeons who have of late written upon the subject. Out of 44 cases extracted from the table appended to this paper, in which the occurrence of pseudarthrosis has been set down by the authors to some particular cause, 22 may, I think, from what is stated, be fairly attributed to motion in the fracture caused by neglect, or entire want of treatment. The information on this point, however, derived from the table, cannot be entirely depended upon, little or no attention seeming to have been directed to it by most of the reporters of the cases.\*

2d. *From the fractured ends being widely separate, or from their not being kept closely in contact.* The nearer the fractured ends of a bone, which has been followed by loss of substance, are laid, the easier will consolidation take place, and though want of union after fractures may undoubtedly follow the first of these causes, yet its occurrence in such cases is not constant. The length of bone that may be removed from fractured limbs and regenerated, often even under unfavourable circumstances, or in debilitated subjects, is truly astonishing. In the case of a boy, ætat. 12, who came under my care in the Pennsylvania Hospital in 1837, two inches of the tibia was removed, notwithstanding which he was discharged cured in eleven weeks with shortening of the limb of but half an inch, the space occupied by the removed bone, being filled by a firm and even callus. Van Swieten (*Commentaries*, i, p. 514, § 343) relates that he saw a fragment of the tibia four inches in length, removed after a fracture, and replaced at

\* To show how far this is the case, I may mention that in one instance (femur) the occurrence of false joint is attributed by the gentleman reporting it, to an attack of cholera morbus, while it is stated at the same time that the patient, who was treated with Amesbury's apparatus, was suffered to move the limb as often as he liked, and to have his bed made every second or third day.

the end of ten months by a firm matter without shortening of the limb. Gooch (*Chirurgical Works*, ii, p. 285) notes a case in which five inches of the tibia was lost, and supplied by solid bone. Mr. Phillips (*Lond. Med. Gaz.* May, 1840) mentions a young man in whom five inches had been removed with a similar result. Lammotte (*Traité de Chirurg.* ii, p. 148) narrates two remarkable instances of a like kind, in one of which six inches of the tibia was removed after the accident, notwithstanding which the fragments were united at the end of eight months without shortening, by a firm callus. Many similar cases are to be found in the records of our science, and all hospital surgeons must have frequently witnessed such, in a greater or less degree.

The consequence of want of close contact between the fractured surfaces is well seen in the patella, olecranon, and os calcis, all of which unite by bone when brought strictly in apposition, but as this is in most cases impossible to effect, are found generally united by a fibro-ligamentous matter of greater or less length, according as the fragments have been more or less widely separated. The difficulty of retaining the bones in close contact in oblique fractures, is, in the opinion of many, a very common cause of deficient bony union. To place the fragments in contact in these cases, extension and counter-extension is kept up, and often the force exerted is in so great a degree, as to cause suffering to the patient, and is by him, or his attendants, relaxed after the departure of the surgeon. At the following visit, displacement is found to exist, and in endeavouring to avoid deformity, the surgeon extends the limb. Pain ensues, and the apparatus is again loosened, and this is repeated until from the constant slipping of the fragments over each other, either the ends of the bone become smoothed off, and as it were cicatrised, with a large and misshapen callus thrown out around each extremity, or else bony matter is not deposited in sufficient quantity to surround the fractured ends, which continue loosely united by means of a fibro-ligamentous matter.

3d. *From disease of the fractured extremities.*—This is particularly the case in compound fractures where necrosis follows. In these injuries, if the periosteum be torn off from the ends of the bone, these parts at once lose their vitality, and the suppuration kept up around the fragments during exfoliation, hinders union from occurring till a late period, in addition to which the long confinement necessitated by such a state, exerts a noxious influence upon the constitution of the patient, and by this means still further retards the work of reparation. The case cited by Faivre (*Ancien Journ.* lxviii, p. 210) was of this kind. The seat of fracture was in the tibia, and had existed for seven months. A portion of the whole cylinder of the bone, one and a half inches in length, was found loose and was removed, and the ends cauterised with a hot iron; six months after which a perfect cure had taken place. Schmucker (*Verm. Chir. Schrif.* quoted from S. Cooper) also relates a case of fractured leg in which necrosis of a portion of the tibia

followed, and no callus was formed at the end of eight months, a sinus remaining on each side of the leg. The sinuses, at the end of the time stated, were laid open, and the dead pieces of bone extracted, by which means the impediment to the formation of callus was removed, and the fracture became firmly united in two months. Sometimes, however, the necrosis is only the remote consequence of the injury. Pieces of bone are completely broken off at the time of accident, but still retain their life, and are embedded in the provisional callus, and when the fracture is almost consolidated these lose their vitality and act as foreign substances, giving rise to inflammation, which destroys in the course of a few days all the solidity of the callus, and postpones for a long time the cure. Mr. Amesbury (*Loc. citat.* p. 197) mentions his having seen a man with a fractured humerus accompanied with necrosis, in which no union took place, and the arm was amputated. I have myself had occasion to observe a fracture of the leg accompanied with caries, in an elderly woman, where union failed to occur, and amputation was performed by request of the patient. Hildanus, (*Opera*, 168, cent. ii, obs. 66,) Duverney, (*Mal. des Os.*) Petit, Heister, (*Surgery*, trans. 1763, p. 128,) and many other authors, have recorded similar facts. Interesting cases in which the development of hydatids in the medullary canal prevented the formation of callus have occurred to Webster, (*New Eng. Journ.* viii, p. 29, 1819,) Wickham, (*Lond. Med. and Phys. Journ.* ii, N. S.,) and Dupuytren, (*Journ. Hebdom.*, xii and ix, 1833,) and Amesbury (*Op. citat.* p. 197) has seen the same thing follow the existence of abscess in the bone. Mr. Arnott (*Lond. Med. Gaz.* June, 1840) amputated the limb of a patient in Middlesex Hospital, in consequence of a fracture of the leg which had occurred in the situation of a node, and remained ununited at the end of a year: the fibula in this case was firmly consolidated. The general rule, however, that broken diseased bones will not unite, is not absolute. Dr. Peirson (*Remarks on Fractures*, p. 38, Boston, 1840) has seen repeated instances of rapid consolidation in bones so diseased as to be broken by a very small degree of force. I had a patient, says Sir B. Brodie, (*Lond. Med. Gaz.* xiii, p. 56, 1833,) "in whom some of the bones had nodes upon them, and were much enlarged. A portion of the clavicle was enlarged, and much diseased besides. This man broke the collar bone through the diseased part. I bound up his arm, and it united as soon as ordinary fractures." In the following case treated by me at the Pennsylvania Hospital, want of union was evidently kept up by a necrosed state of the inferior fragment, after the removal of which a perfect cure was effected.

The patient was a healthy farmer from Clearfield county, Pennsylvania, aged thirty, who was received on the 9th of August, 1837. He stated, that on the 29th of May previously, a loaded wagon had passed over his arm and produced a simple fracture, which was dressed by a neighbour, with three board splints fastened tightly by a bandage around the injured part only. On the second day after its application, in consequence of violent pain at the seat

of fracture, and great swelling of the hand and fore-arm, a physician was brought to him from a distance of many miles, who removed the dressings. Upon removal, the soft parts at the anterior and inner side of the arm were found to be mortified, and in twelve or fourteen days afterwards, separated, and left the bone projecting some two or three inches. He suffered during this time from severe inflammation of the arm, accompanied by fever and a profuse discharge of pus; and after recovering in a measure his strength, he set off on foot for Philadelphia, where he arrived the evening before entering the hospital. The seat of fracture was found to be just below the insertion of the deltoid muscle, and the inferior fragment protruded through an opening only large enough to admit of its passage. The end of this fragment was of a yellowish white colour, and deprived of periosteum for the space of an inch or more, and not loose. No bony union had taken place. There was a small discharge of pus from the part, and no pain was experienced on handling and examining it. A good deal of hardening existed at the point of fracture, but it appeared to be rather from thickening of the different tissues, than from a deposit of callus. His general health was good. On the 30th of September the projecting portion of the bone was found to be loose, and was removed; after which the wound soon closed, and union begun to take place. By the 1st of November union was perfectly firm.

4th. *The interposition of foreign bodies between the fragments,* has been generally stated among the causes which may retard union. Portions of bone which are completely detached, bullets or other foreign substances, sometimes remain between the extremities, and by keeping up profuse and long continued suppuration, so debilitate the system as to prevent the formation of callus, and give rise to this state. Rossi (*Thèse sur les Résections*, by M. Roux) notices a case of ununited fracture of the humerus, amputated by him after the resection of the extremities had been unsuccessfully resorted to, in which the cause of non-union was found to be a ball contained in the medullary canal a little above the false joint. In some rare instances, however, nature removes the irritating effects of the foreign body, by giving it a covering of dense fibrous structure. A remarkable instance in which this happened after fracture of the femur, is reported by M. Vogelvanger. (*Gaz. Médicale*, p. 445, 1838). Two years after the accident the patient died, and M. V. found a piece of iron thirty-five lines in length, and five in breadth, completely surrounded by a deposit of callus.

Slips of muscle, or of tendinous matter interposed between the fragments, has also been stated as one of the causes of want of union. That in some instances these parts are found lying between the fractured extremities there is no doubt, but that it ever proves in itself a cause of non-union, I am not disposed to admit. In all of the instances in which I find it mentioned as having existed, it is also stated that the fracture has been oblique, and the fragments more or less separated from each other. When this state of things exists, any soft parts in the neighbourhood of the fracture are necessarily forced into the space

between the bones, and so remain until a proper position is given to the limb and the fragments perfectly reduced; and where from the size of the intervening part this cannot be at once done, the mere continued pressure of the ends of the bone would in a very short time, if properly adjusted, either cause its absorption, or else cause it to take on the ossific action. The interposition of any soft parts between the ends of a fractured bone, is justly regarded by Mr. Key (*Lond. Med. Gaz.* iv, p. 264) as a mere excuse for the occurrence of non-union. "It is the duty of the surgeon," he observes, "when he examines into the nature of the accident, and places the limb in splints, to ascertain that the fractured ends grate together; and if muscle is interposed, to make extension in order to disengage the broken extremity." The case mentioned in the Dictionary of Cooper, on the authority of Sir James Earle, is often quoted to show the possibility of muscular substance forming an impediment to the union after fractures. He says, "I have seen a woman, under Sir James Earle, in the above hospital, (St. Bartholomew's,) whose os brachii did not unite, though it had been broken several months. Every attempt to move the bone occasioned excruciating torture. The woman died of some illness in the hospital; and, on dissecting the arm, the cause of the fracture not having united was found to arise from the upper, sharp, pointed extremity of the lower portion of the broken bone having been forcibly drawn up by the muscles, and penetrated the substance of the biceps, in which it still remained." From this it is clearly evident that the fracture was oblique, and the fragments much displaced; and this want of apposition in the fragments is surely alone a sufficient cause for the non-union, without seeking for it in the interposition of muscular fibres between the fragments. Besides, it is well ascertained that muscle, as well as all the other parts surrounding a fractured bone, contribute more or less to the formation of the callus. An interesting preparation going to support this view, and much to the point in this particular matter, is mentioned in the *Dictionnaire de Médecine* (xiii, art. Fract. 2d ed.) as having been presented to the Anatomical Society of Paris, in which the fragments of a clavicle, separated to the extent of an inch by the subclavian muscle, were united together very solidly by two bridges of newly-formed bone, in the centre of which the muscle, *itself ossified*, was imprisoned.

*5th. Tight bandaging.*—That a tight bandage may prevent the restorative process from taking place there can be no doubt. Duverney (*Diseases of the Bones*, trans. by Ingham, p. 171, 1762) thinks, nothing in simple fractures so much opposes the formation of callus as a too tight bandage. Paré, (*Works*, trans. by Johnston, p. 379, 1649,) and Wiseman, (*Chirurgical Treatises*, ii, p. 256, 5th ed. Lond. 1719,) also caution us in regard to its employment. Sir B. Brodie explains its modus operandi, by supposing that the fracture does not receive a sufficient quantity of blood to allow of the process to go on; but M. Malgaigne, with more reason, attributes it to the pressure preventing the deposit of the provisional callus. In support of the

view of the latter it may be remarked, that Troja long since satisfied himself by experiment, that moderate compression in no way interferes with the process of reunion after fractures, but showed that a bandage tightly applied, without, nevertheless, being so much drawn as to cause any serious accident, prevented the formation of the provisional callus and its consequent consolidation.

6th. *The long continued use of cooling applications*, by keeping down vascular action in the fractured part, is ordinarily given as one cause of tardy union. These applications should never be continued after the subsidence of the acute inflammatory symptoms. By Mr. Amesbury, diminished action from the too long continuance of sedative or cooling lotions, is regarded as a frequent cause of tardy union. (*Op. citat.* p. 198). Dupuytren regards them in the same light.

7th. *The too early use of a fractured limb* sometimes causes absorption of the callus to such an extent as to permit of motion in the part; and if in such instances the moving about is continued, the friction kept up between the ends of the bone causes them to become rounded, at the same time that the surrounding tissues become thickened, and form a false joint.

Though the above are all at times the cause of firm union being wanting after fractures, yet it must be confessed that want of consolidation occurs in some instances, without our being able to trace it to any particular cause. One of the most authoritative writers on the subject of ununited fractures, is unwilling to admit that in these cases, a cause cannot always be found. On this point, he thus expresses himself: "I have examined fifty-six cases of non-union, exclusively of those which I have witnessed in the neck of the thigh bone, olecranon and patella. The constitutions of three of these were decidedly bad; another had been much reduced by cholera, during the recent state of the fracture. The remaining fifty-two, apparently, possessed constitutions, and enjoyed health equal to the most vigorous and healthy individuals that came under observation." "In these cases, with the exception of two which occurred during pregnancy, where constitutional causes might, under any treatment, have operated in a measure so as to retard the union, I think the cause was purely local; and for the most part, if the treatment had been such as to secure the fractured parts in proper apposition, and in a state of quietude, the fractures would have united at an early period." (*Amesbury, Loc. citat.* p. 202.) The experience here given is valuable, though allowance is to be made for any mere opinion on this subject from its author, inasmuch as his theory of the cause, or mode of production of ununited fractures, was brought forward to support arguments for the use of his peculiar apparatus in the treatment of these accidents. Equally good observers, and careful practitioners, differ in belief from him, and that it sometimes happens that no firm union will take place in persons enjoying apparent perfect health, even when regularly and judiciously treated, must be admitted. An instance of

ununited fracture is mentioned by Mr. Samuel Cooper (*Dictionary Ed.* 1838, p. 551) which occurred in a strong and robust man, whose chief peculiarity seemed to be his indifference to pain, where the ends of the humerus were cut down to, turned out, and sawn off by Mr. Long, in St. Bartholomew's Hospital, and the limb was afterwards put in splints, and taken the greatest care of; but no union followed. He also notices another case of a broken tibia and fibula, occurring in a subject who was a complete instance of hypochondriasis, which remained disunited for about four months; but afterwards grew together. M. Sanson (*Dict. de Med. and Chir. Prat.* iii, p. 494) cites three cases of fractures, one of the leg and two of the thigh, that required from five to ten months of treatment before union was perfect; and two cases of false joints in the thigh, in which it was impossible to attribute this state of things to any appreciable cause. Latta states that he had met with three instances of fractures purely transverse, in which, notwithstanding all the care that could be taken, no callus was formed. (*System of Surgery*, iii, p. 362.) Ruy sch and Van Swieten have reported several like facts, and other cases might readily be brought forward.

So often indeed, does non-union occur after the most regular treatment, that we should be cautious in ever attributing this state of things to any fault of the surgeon. That want of care in the treatment on the side of the practitioner, or restlessness on the part of the patient, does not hinder the formation of callus in large quantity, must have been noticed by every one. In bad compound fractures, the large discharge of matter from the wound, not unfrequently requires that the limb be daily moved, and the fragments are consequently much oftener disturbed than occurs in the treatment of simple fracture, and yet false joint is not as frequent in the former, as the latter class of cases. How often do we see cases that have been carelessly treated, or even entirely neglected, where union, though attended with deformity, takes place? How often where two bones existing in the same limb have been fractured, do we find, that one will unite and the other not? How many cases too have been observed, where more than one fracture has existed in the same individual at the same period, and where, though all be equally well treated, want of union will follow some one of them? If non-union depended generally upon want of perfect rest in the injured part, the bones that are with most difficulty retained in apposition after fracture, are those, in which we should expect most frequently to meet with it. The clavicle, comparatively speaking, is rarely the seat of ununited fracture, and yet did it depend upon mobility, that bone of all others, is the one we should find most frequently affected with it. The ribs we daily see well united after fractures, despite the constant motion to which they are subjected in respiration. In animals, Sir B. Brodie (*Loc. cit.* p. 57) asserts, that he has tried, over and over again, to prevent union by giving motion to the broken bones several times a day, but has never succeeded, and, indeed, thought that union seemed to go on more rapidly where the limbs were thus

exercised, then when they were not disturbed. Union, however, we know takes place with great facility in animals, and the knowledge of this fact proves of itself nothing conclusively in regard to fractures in man; but surely the known uniformity of nature's laws, when taken in connection with the facts we have just adduced, should make us pause before positively asserting that motion is always the cause of ununited fractures—more especially when, as is sometimes the case, an opinion is required which may irreparably injure a fellow practitioner. Causes may be suggested for this state of things, some of which may seem plausible, or be shown to be true with regard to particular instances, but in many cases its occurrence cannot be satisfactorily accounted for. That the state of the constitution has considerable influence over the process of reparation in fractured bones, none can deny—where the lancet has been largely used after the accident, where patients are much debilitated, or are labouring under constitutional diseases, the process may be retarded; but where the peculiarity of constitution which renders the vessels of the injured part incompetent to furnish bony matter does not exist, we find generally the deposite of callus to take place, upon this morbid state of system being removed. Schmucker (*Vermischte Chir. Schriften*. quoted from *S. Cooper*) found the formation of callus, even in the most simple fractures, sometimes delayed eight months, and in one example, more than a year; but all the patients were unhealthy. Even after a fractured limb has become perfectly firm, and is surrounded by a large mass of callus, it is possible for it to become softened, or even entirely absorbed, during an attack of general fever, erysipelas, or other acute affection. I have in two or three instances, witnessed the first of these effects produced by attacks of erysipelas in compound fractures, when the disease has prevailed generally in the wards of the Pennsylvania Hospital; and in one instance of simple fracture, have seen a rapid absorption of a large callus, which had produced firm union of a fracture of the lower third of the leg, occur without any apparent cause, to such an extent, as to render the fragments very movable, and necessitate a renewal of the treatment. This absorption, or softening of the callus, has been observed by Mead, (*Medical Works*, p. 442,) in a sailor, attacked by scurvy, in whom, three months after firm union of a fractured clavicle, the callus became softened and gave way; in this case the general affection is stated to have retarded for more than six months, any new union. In speaking of the ravages of the scurvy during his voyage, Lord Anson makes mention of a man on board the Centurion, in whom "the callus of a broken bone which had been completely formed for a long time was found to be dissolved, and the fracture seemed as if it had never been consolidated." Another like instance has been recently observed by Dr. Budd. (*Tweedie's Cyclopedia—Art. Scurvy.*) We find recorded by Desault, (*Journ. de Chirurg.* i, p. 243,) the case of a fractured femur occurring in a woman, aged 82, where consolidation took place by the seventy-fifth day, but in

whom, two months after, death occurred from severe diarrhoea, and the callus was found completely softened. Morgagni (*French Translation*, ix, p. 159, Paris, 1820) quotes from Salzmann, the case of a soldier with fractured tibia, in whom union had become so firm as to allow of his walking upon the limb without difficulty; but during an attack of fever, eight months afterwards, the callus was noticed gradually to disappear, so that the ends of the bone became separated. After convalescence, the parts again become firm. Dr. Schilling has seen the callus deposited around the ends of a fractured femur, which had become so firm as to allow the patient to bear some weight upon the limb, completely absorbed during an attack of typhus abdominalis. Ten days after the symptoms set in, callus could no longer be felt, and the bones moved as easily upon one another as immediately after the reception of the injury. In six days more the patient died. The examination showed no trace of callus, the broken surfaces were bloody, like those in a recent fracture, and were surrounded by a sac-like membrane, which contained some black bloody fluid. (*British and Foreign Med. Review*, 1840.) Mr. Mantell has recently published the case of a youth, aged seventeen, (*Lancet*, i, 1841-2, p. 58,) who, some weeks after the perfect cure of a fractured leg, was seized with a severe attack of fever, and upon first leaving his bed after the subsidence of it, the limb bent under him in consequence of the callus having become soft, and giving way. As recovery from the fever proceeded, new callus was formed and reunion of the fracture was effected, though with much deformity of the limb. In the thesis of M. Bérard, I find another instance, quoted from Bonn, where fever with inflammation and gangrene, occurring in an old man, who had suffered from fracture of the femur that was firmly united, produced absorption to such an extent, as to allow the fragments to become movable one upon the other. Dr. Penel, (*Lond. Med. and Phys. Journ.* xiv, p. 29, 1805,) Surgeon to the Civil and Military Hospital at Abbeville, furnishes the case of an elderly man with fractured thigh, in whom, on the fortieth day, union being solid, the dressings were removed, and the limb laid on a bolster; but suddenly the callus was destroyed, and it was necessary to make continued extension to reduce the fractured bones: at the same time the urine was observed to deposit a considerable quantity of a greenish substance, which on examination was found to be phosphate of lime. The fracture seemed again to consolidate, the urine however remained the same, and was passed in a greater quantity. Two months after the fracture, the callus appeared a second time firm. The dressings were continued twenty days longer; but two days after their removal, the extremities of the fracture separated, and it was necessary again to make the reduction. He now gave the patient 3ss of nitric acid daily, when the urine became clearer, and four months after his first reception the dressings were removed and the limb found to be firm. From some cases published by M. Guyot, (*Arch. Gén. de Méd. Feb. 1836*,) it appears that an inflammatory action in

the callus alone, unaccompanied by any other affection, and ensuing several weeks after the accident, occasionally produces softening and absorption of the newly formed bone, and ultimately disunion of the ends. Duverney, (*Op. citat. preface,*) Malgaigne, (*Lancette Française*, iii, p. 217, 1830,) Wardrop, (*Med. Chir. Trans.* v,) Kirkbride, (*Amer. Journ. of Med. Sciences*, xv, 1835,) and Vidal, have all witnessed cases of absorption of the callus, in acute local disorders. This softening, or absorption, however, affects the provisional callus alone, and is consequently seen only in the first few months that follow a fracture; at a later period, when the definitive callus is completely formed, the bone becomes more dense and firm than it originally was, and is never absorbed. The following well attested case, in which, not only the callus resulting from a fractured humerus, but the whole bone was slowly absorbed, is, we believe, without parallel in the records of surgery.

Mr. Brown, residing in Derne St., Boston, aged 36, when in his eighteenth year, fractured the right humerus near the middle. Under the care of a judicious surgeon, a reunion was favourably going on; but before the curative process had been completed, the patient had another fall, and again broke the arm at the seat of the old fracture. Notwithstanding every care, the divided extremities would not adhere; and to the surprise of the medical attendant, the shaft of each part of the divided bone began to diminish in size, and shorten in length. By a gradual action of the absorbents, the whole of the arm bone, between the shoulder and the elbow, was at length completely removed, and that too, without any open ulcer, so that not a vestige of it was left. Mr. B. now, after many years, presents the spectacle of one short and one long arm. The right fore-arm and hand are of a size to correspond with the sound one on the left side, and under certain circumstances, are equally as strong. Ordinarily, the right arm swings hither and thither, like a thong with a weight at the extremity; for the fore-arm and hand, with reference to the division above the elbow, constitute a pendulum, oscillating according to the movements of the body. Although it is impossible to push with the defective arm, he can draw a burden towards himself with it as strongly and tenaciously as with the other; and in so doing, the muscles are elongated, so that the arm is extended to its original length; when the resistance is removed, the muscles instantly shorten themselves about six inches. To show the perfect non-resistance of the apparatus of muscles, arteries, veins and nerves in the soft, boneless space, we saw him twist the palm of the hand twice round, which consequently presented the strange anomaly of having all the apparatus of the arm twisted like the strands of a rope. (*Boston Med. and Surg. Journ.* July, 1838, p. 368.)

Cases of pseudarthrosis sometimes occur which occasion so little inconvenience as scarcely to interfere with the use of the parts in which they may be situated; and under such circumstances, it is more than doubtful whether

any operative means should be recommended for their cure. In the *Nouvelles de la République des Lettres*, of Bayle, a case is recorded by Sylvestre, in which an ununited fracture of the fore-arm, four inches above the wrist, in no way prevented good use of the limb. Kuhnholtz (*Journ. Complémentaire*, iii) has given an instance in which an ununited fracture, situated in the thigh, interfered but little with the use of the limb. MM. Sanson (*Velpeau, Médecine Opératoire*, i, p. 599, ed. 1839) and Yvan (*Archives Gén. de Méd.* xix, p. 619) have seen like cases. A patient came under the notice of M. Cloquet, (*Archives Gén. de Méd.* xix,) in whom the upper fourth of the humerus had been lost, without in any way interfering with the motions of the arm. M. Velpeau (*Gorré. Thèse*, No. 218, 1835) noticed some years since, at La Pitié, a man with an ununited fracture of the clavicle, in whom all the movements of the arm were executed without difficulty. M. Gras (*Journ. de Méd. Chir. and Pharm.* in 40 vols. viii) gives an instance of an ununited fracture of both bones of the fore-arm, at the inferior part, from gun-shot, which gave so little inconvenience that no operation was attempted. Horeau (*Journ. de Méd. Chir. and Pharm.* x) has furnished a case situated in the lower jaw, in which, although mastication was somewhat affected, yet was so little annoying, that the patient was not willing to undergo any treatment for it. Mr. Syme (*Edin. Med. and Surg. Journ.* July, 1835) has seen want of consolidation in the humerus and fore-arm, where the fracture was transverse, accompanied with very little inconvenience. I have myself seen a young Irish woman with an ununited fracture of the clavicle, in which, although great motion existed between the fragments, so little inconvenience was experienced, that it was not judged proper to resort to any treatment for it; and in 1839 a case of false joint in the radius, two and a half inches above the wrist, came under my notice, where the patient enjoyed excellent use of the member, and notwithstanding some deformity, was able to work at his trade (that of a tailor,) as well as if no accident had happened.

Even in cases where the want of bony union in fractures has not permitted the patient to make use of the limb, we often find that by the employment of simple means the defect may be rendered supportable. M. Troschel (*Journal des Progrès*, x, p. 257) mentions three instances in which, by the application of tin splints fitted to the limbs, the persons were enabled to walk without difficulty. Monteggia (iv, p. 28) relates the case of a monk in whom existed a non-consolidated fracture of the middle of the fore-arm, and who, by means of an appropriate apparatus, could make use of it for all ordinary purposes. M. Velpeau (*Op. citat.* ii, p. 582) examined an ununited fracture of the thigh in a female, who, with the aid of a clumsy apparatus continued to make good use of her limb. Delpech (*Dictionnaire des Sciences Médiçales*, iii, art. *Cal.*) has seen a workman with a non-consolidated fracture of the femur, who by means of a case for the thigh, was enabled to pursue his usual employments. Mr. Linton (*Lond. Med. Repository*, Feb.,

1824, p. 93) furnishes the case of an Arab sheik, affected with a fracture of the right humerus, accompanied with great loss of bone, that had never united, in which a circular silver tube, six and a half inches in length, was worn with ease, and permitted him to do good service with his sword. Dr. Betton, of Germantown, mentioned to me an instance which came under his notice, in which no union had occurred after a fracture of the humerus, where a pasteboard splint, made so as to surround the arm, was worn with such good effect as to allow the man to apply himself to his usual employment. In his retrospective address in surgery, delivered at Liverpool in 1839, (*Provin. Med. and Surg. Trans.*, viii,) Mr. James mentions, that having failed in obtaining union of the bones of the upper arm by excision of their ends, in a case where a seton could not have been passed, he had recourse to an external apparatus, which appeared to answer the purpose of giving stability to the limb so well, that he "should feel very reluctant to undertake a severe operation again for this defect, unless on further trial the apparatus was not found to succeed." Larrey (*Clin. Chirurg.* iii, p. 461) even goes so far as to recommend in all cases of fracture, where the usual means are insufficient to effect consolidation, that they be left to nature. The patients, he says, accustom themselves to this infirmity, of which the effects diminish with time and exercise, and they finish by being able to use the affected limb with the aid of a pasteboard splint to envelope it: three cases are related by him, all of whom, despite the existence of false articulations in the arm, were able to perform the ordinary duties of soldiers. More lately, the same surgeon has exhibited to the Academy of Surgery (*Dictionnaire de Médecine*, xiii, p. 482, 2d edit.) an invalid affected with a disunited fracture of the femur in its middle, of several years standing, where, although the member was shortened, and the fragments very movable, the patient by means of a high-heeled shoe, made use of his limb without the aid of crutches. Instances have occurred in the leg, where one of the bones only being broken and remaining disunited, the other has become enlarged to such a degree as to support well the whole weight of the body. A very remarkable example of this sort, in which the tibia remained ununited, while the fibula, which had remained perfect, increased exceedingly in size, and performed the office of the tibia in supporting the body, is mentioned by Dr. South (*Otto, loc. cit.*, p. 224) as having been in the museum of St. Thomas's Hospital, and Sir Astley Cooper, in his work on Fractures and Luxations, figures a case of a similar kind. Such instances are rare.

In the majority of cases, however, the extremities affected by pseudarthrosis become almost useless, and resort to operative means is demanded by the patient. Up to the time of White, so few were the cures by the methods then in use, the majority of persons labouring under these affections had only the choice of retaining a useless limb, or of having it removed by amputation; but now, thanks to the progress of our science, many different methods are offered for their relief, of which the following are the principal.

1st. *Friction*, or rubbing the extremities of the bone against each other. This method is mentioned by Celsus, and appears to have been that usually adopted by the surgeons of his time. "If the fracture be of long standing, the limb is to be extended, in order to produce a fresh injury: the bones must be separated from each other by the hand, that their broken surfaces may be rendered uneven by the grating against each other; and if there be any fat substance, it may be abraded, and the whole reduced to the state of a recent accident; yet great care must be employed, lest the ligaments or muscles be injured. (*Liber. 8, Cap. 10, Lee's Trans. ii, p. 422.*) John Hunter recommended it. In some cases where the union is delayed, the mere removal of the splints and leaving of the limb free and without apparatus of any kind, will produce sufficient action in the ends of the bone to bring about firm union. Sometimes the friction is made by seizing the extremities of the bones, and strongly rubbing one against the other; this is to be done daily until the parts become painful, when the ordinary apparatus is to be applied for the purpose of keeping the fracture in a state of perfect rest. At the end of ten or twelve days the limb should be examined, and if union is not excited, or at least some stiffening have been produced, the process is to be again repeated. Another method, often resorted to in the lower extremities, of making frictions of the ends of the bones, consists in enveloping the limb in pasteboard, previously softened, a leather case, or other suitable apparatus, and then suffering the patient to move about and bear weight upon it as usual, in order that the friction, the "stimulus of exercise," should bring about such a degree of irritation as would lead to the deposit of callus. A state of perfect rest, however, it should always be remembered, is necessary to the proper and speedy union of fractured bones; and this fact should not be forgotten in the application of the treatment here mentioned, to the cure of ununited fractures, so that, so soon as the proper degree of irritation is once effectually produced, the patient should be placed in a state of quietude, and his affection treated as a recent injury. The continuance of exercise, or frictions, after the occurrence of irritation, would retard rather than accelerate the firm union of the fragments.

2d. *Blisters applied to the seat of fracture*, were proposed by Mr. Walker, of Oxford, in 1815. (*Lond. Med. and Phys. Journ. xxxii, p. 470, 1815.*) This method is peculiarly adapted to cases which are tardy in uniting. They appear to act by exciting the periosteum, and parts about the fractured ends, to increased action; and the same effect may be produced by an attack of inflammation in the limb. An interesting instance of the effect of this latter is given by Seerig. (Quoted from *Archives Générales* for Jan. 1839, p. 105.) The patient, who had refused all treatment, was seized, without any apparent cause, with erysipelas of the limb, which produced its consolidation. Mr. Wardrop (*Med. Chir. Trans. v, 1814*) mentions a case of fractured humerus, where union went on rapidly after contusion of the part, although there previously seemed to be no disposition towards it.

Dr. Kirkbride (*Amer. Journ. of the Med. Sciences*, No. xxxiii, 1835) also mentions a case in which an attack of erysipelas, after the passing of a seton, appeared to hasten considerably the consolidation of the bone. Another instance, in which the inflammation produced by an accident was sufficiently great to cause consolidation of an ununited fracture, is reported by Mr. Amesbury. (*On Fractures*, 2d ed. 1829, p. 210.) "A gentleman had a fracture in the thigh, in which no union could be produced. Several months after his accident he was thrown out of his gig, and the wheel passed over the limb at the fractured part. He was confined after the second accident, which was followed by high inflammation; and now the fractured bone united."

Sir B. Brodie (*Lond. Med. Gaz.* xiii, p. 57, 1833) asserts that he has found very great benefit from the use of blisters, in cases which are not of long standing. In cases of tardy union, to which they are particularly applicable, I have in more than one instance witnessed a very rapid deposit of callus after the application of blisters to the seat of fracture. From the nearness of the tibia to the surface, their employment is peculiarly adapted to fractures of this bone, and are much more likely to prove successful in it, than where the bones are deeply covered with soft parts. Even in the superficial bones, however, they sometimes fail. An instance of this kind occurring in a lady who had a fracture of the tibia at the small of the leg, in which they were tried for a long time without benefit, is mentioned by Amesbury. (*Loc. citat.* p. 212.) Mr. Walker made use of blisters of small size, and repeated their application as often as five or six times. Velpeau recommends that they be sufficiently large to surround the limb. In those instances in which I have witnessed their employment, they were made of such size as to cover completely the seat of injury.

3d. *Iodine.* The treatment of non-union after fracture by the application of iodine to the injured part, was first proposed by Mr. Buchanan, of Hull, in 1828. (*On a New Method of Treatment for Diseased Joints and the non-union of Fractures*. London.) He applied it in the form of tincture, by daily painting over with a small brush the parts covering the false joint. In the case reported by Mr. B., the Hunterian method was at the same time resorted to, and a perfect cure was obtained in four months, though the Hunterian method alone had been unsuccessfully tried previously to the application of the iodine, for six months. The same remedy has been since made use of with good results by Mr. Crosse, (*Lond. Med. Gaz.* vi, p. 512, 1830,) and Dr. Willoughby. (*Trans. of Med. Soc. of state of N. York*, i, p. 76, 1834.) According to Oppenheim, (*Loc. citat.* p. 3,) it has also been successfully repeated by Trusen, in Germany. The efficacy of the iodine in these cases can only be owing to its stimulating properties; and in some instances of slow union, where blisters are objected to, it might be worthy of trial.

4th. *Compression.* Mr. Inglis, in 1805, (*Edin. Med. & Surg. Journ.* i, 1805,) adopted this plan of treatment. In his case a considerable degree

of pressure was made over a tin-plate, placed over the seat of fracture, by means of a roller. In this instance, however, as also in one which occurred several years previously to White, in which nearly a similar plan of treatment was pursued, the pressure was combined with frictions, the patients being permitted to move about after the application of it. Pressure conjoined with perfect rest, or as it has been termed, still pressure, was first proposed by Mr. Amesbury, and has been highly lauded by Dr. Wright of Baltimore. In some instances it has been produced by means of the peculiar apparatus of the former of these gentlemen for the treatment of fractures, while in others, it has been applied by means of a tourniquet passed around the seat of injury, the part being previously enveloped in splints, or the immovable apparatus. We are totally without facts to show that pressure and rest alone are sufficient to bring on such a degree of action as is necessary to produce union where the pseudarthrosis has been of long standing, and is itself unaccompanied by inflammation of the periosteum or parts about. It cures solely by immovability, and is consequently only applicable to such cases as occur within the period in which the permanent callus is produced.

5th. *Electricity* has been employed with good effect by Mr. Birch, of London. One of the pupils of this gentleman informed Dr. Stevens, of New York, that he had seen two cases in which it produced the most happy effect. One of these cases was seated in the leg, and was of thirteen months standing. "Shocks of electric fluid were daily passed through the space between the ends of the bones, both in the direction of the length of the limb and that of its thickness. The man being somewhat weak, used bark and porter at the same time. The leg was retained in the ordinary fracture dressing. Improvement was very perceptible in two weeks, and in six weeks he left the hospital cured." (*Transl. of Boyer by Stevens—note.*) Two cases, however, have been reported by Dr. Mott, (*Med. and Surg. Reg.* part 2, i, p. 375,) in which "very powerful shocks of electricity were passed in different directions through the part" without benefit.

6th. *Salivation.* This method of cure for disunited fractures was employed successfully in 1830, by Sir Stephen Hammick. Speaking of the cure of these fractures, this author says, "Mercury will frequently be required by patients who never had any syphilitic taint, not only to act as an alterative, but even it will be necessary to push it to a considerable extent before union of a fractured bone will take place." (*Lectures on Fracts., Amps., &c.* p. 118.) Mr. Colles, of Dublin, has also seen cures take place in these cases, by the administration of mercury; and in an instance that he witnessed at Guy's Hospital in 1836, under Mr. B. Cooper, which had proved rebellious to other modes of treatment (seton, frictions, and the immovable apparatus), he suggested its trial to that gentleman. (*Guy's Hospital Reports*, ii, p. 399, 1837.) The patient was a healthy female, æt. 28, and the fracture, which was at the humerus near its middle, was of six months standing. Four weeks after the removal of the seton, salivation was produced by the administration of four grains of hydrargyrum cum creta, three times a day,

and at the same time a leathern girth was firmly applied over the seat of fracture. The girth was removed at the end of a month, and a perfect cure was found to have taken place. In this instance, we are disposed to attribute the cure as much to the pressure over the seat of fracture made by the leathern band, as to the administration of mercury; and this view of the case we are the more inclined to adopt, as we find that three months after cure, she re-entered the hospital, with a fracture of the same arm below the part at which it was first broke, which by the application of the same girth was cured in the usual period. In a case at the Middlesex Hospital of London, Mr. Arnott failed to effect a cure by mercury, and Mr. Charles Hawkins asserts, that he has seen mercury freely administered in three cases that had come under his observation, without benefit. (*Lancet*, ii, 1839-40, p. 382.)

*7th. The application of caustic alkali to the integuments over the seat of fracture.* In 1805, Dr. Hartshorne of this city (*Eclectic Repertory*, iii, p. 114, 1813) successfully employed this practice in a case of ununited fracture of the external condyle of the femur of four months duration, and in 1811, he applied the same practice to a disunited humerus of about five months standing, with the effect of partially relieving the patient: in this last case the issue was three inches long and one wide. A third case occurring in the femur, about which he was consulted in 1838, was cured by the caustic conjointly with pressure. (*American Journ. of Med. Sciences for Jan'y*, 1841, p. 143.) An eschar three inches long by one wide, made on the arm with the caustic potash, where the injury was of six months standing, proved ineffectual in a case which afterwards came under the care of Dr. Hays. (*American Journ. of Med. Sciences for Jan'y*, 1841, p. 141.) The actual cautery has also been employed in these cases. As with the application of blisters, and moxa, these means are particularly adapted to instances of tardy union, and in bones seated superficially, as the tibia and ulna, and the condyles of the femur.

*8th. Seton.*—The mode of managing false joints with the seton is said to have been first proposed by Winslow. (*Tode's Arzneikundigen Annalen Kopenk*, 1787. This work, which I have had no opportunity of consulting, is quoted on the authority of Richter, from his volume on Dislocations and Fractures, published at Berlin in 1833.) To the late Professor Physick, however, are we indebted, if not for its discovery, at least for having first demonstrated its value, and introduced it into general use. (*Medical Repository*, i.) The first case in which it was used by Dr. P. was in 1802. The fracture was seated in the humerus two and a half inches above the elbow, and was received on the 11th of April, 1801. The fragments passed each other about an inch. On the 18th of December, 1802, a seton was passed between the fragments of the bone. The pain of the operation was moderate, and the inflammation that followed was not severe. For the first twelve weeks there was no evident abatement of motion, but after this time it became gradually more stiff, and by the 4th of May, 1803, it was per-

fectly firm, and the seton was removed. Some time afterwards, Percy of France treated a non-united fracture of the femur by the same means, which succeeded so well, that in two months after the operation the patient was enabled to walk without crutches.

9th. *Setons near the extremities of the bone.*—Sometimes the seton cannot be passed between the fractured ends of the bone, in consequence of their being surrounded by a large cartilaginous or bony mass. In such cases, or where from other causes, the seton as usually placed has failed, M. Oppenheim proposed in 1828, and advocates, the passing of two setons, not as Dr. Physick advises, through the intermediate substance, but close to the bone near to the extremity of each fragment, and recommends that they should be permitted to remain no longer than is sufficient to establish free suppuration. (*Oppenheim, op. citat.* p. 15.) Two cases are given by him, one of the humerus, in a male æt. 30, and the other of the fore-arm, in a female æt. 44, in which this mode of practice was adopted with good results. In 1833, Saaurer also passed a seton around the tibia near the point of fracture. He made incisions down to the bone both internally and externally, and then pushed a seton-needle, half an inch broad and somewhat curved, through the external incision around the extremity of the bone, and drew it out through the internal wound. Considerable inflammation and suppuration followed, and the seton was removed on the tenth day; three months after the operation the patient was able to resume his field labours. (*Oppenheim, op. citat.* p. 15.) The same practice has been recommended by Mr. Gulliver, and Mr. Rhynd of Dublin. In either of the above methods where the seton is slow in exciting a sufficient degree of action in the parts, it has been recommended to smear the cord with stimulating ointments, as the unguentum cantharidis, or the unguentum oxidi hydrargyri rubri, &c.

10th. *The passing of a ligature around the ligamentous mass connecting the fragments, and tightening it daily by means of a screw.*—This method has been adopted successfully by Seerig. (*Troschel de Pseudarthrosi, quoted from Arch. Gén. for Jan. 1839,* p. 105.) Longitudinal incisions, two inches in length, were made on each side of the fractured bone, and the fragments separated one from the other: a needle in the shape of the letter S, to which a ligature was attached, was then passed around the substance connecting the ends of the bone and the extremities attached to the serre-nœud of Græfe, which was tightened daily until the sixteenth day, when it dropped off.

11th. *The introduction of a wire between the fractured ends of the bone.* This operation has been practised by Dr. Somm , of Antwerp, in an ununited fracture of the femur of five months duration. The wire was employed in preference to the silk seton of Dr. Physick, as M. Somm  judged the latter to act only on a small surface of the fragments, while by his method, all the points of surface of the fragments would be irritated, and that successively, so that at no time could the irritation become dangerous. The operation is thus described. “The left femur was broken obliquely about the middle,

and the fractured extremities rode over each other, the lower inwards, and the upper end outwards. The patient being placed on his back and supported, I passed a long trocar and canula, at first downwards on the inner side of the upper fragment and made it pierce the skin behind, and a little to the outside; the trocar was then withdrawn, and a silver wire passed through the canula and out at the posterior opening. The canula was then withdrawn, and being replaced on the trocar, they were introduced again above and on the outside of the lower fragment, and made to pass out at the same opening behind. The trocar having been removed, the other end of the wire was passed through the canula so that both ends were in contact behind, leaving a loop in front. I then made an incision in front, from one orifice to the other made by the trocar, and drawing the extremities of the wire through the wound, brought the loop between the fractured ends of the bone, and approximated the edges of the skin with sticking plaster." The limb was kept at rest in a fracture box. At each dressing, the wire was drawn down, so as to depress the loop more and more into the flesh. No bad symptoms followed. Six weeks after the operation, which was done the 12th of August, 1828, the union was distinct, but the wire was not withdrawn till the 2d of October. The apparatus was continued to the limb until the middle of November. The patient is stated to have recovered without apparent shortening of the limb. (*Med. Chir. Trans.* xvi, p. 36, 1830.)

12th. *Acupuncture.* Malgaigne, in 1837, attempted the cure of a disunited femur, in its lower third, by acupuncture; but although mobile, the fragments were in such close contact, that of thirty-six needles introduced at different points, he could not succeed in passing a single one between the extremities of the bone. (*Manuel de Méd. Opérat.* p. 251, ed. iii.)

13th. *Scraping or rasping the fractured ends of the bone.* This process was well known to the ancients. Avicenna describes it, and speaks of a philosopher who died from its effects. Guy de Chauliac notices this case mentioned by Avicenna, but to condemn it, and blame the philosopher, who, he says, "would have better merited this title by living with a halting gait, than by having the callus scraped and dying in great torments." (Boyer, iii, p. 106). John Hunter irritated a false joint seated in the humerus with a spatula, after laying it open, with success; and Sir B. Brodie, on whose authority the statement is made, (*London Med. Gazette*, xiii, p. 56, 1833,) thinks that "in all probability Dr. Physick borrowed his idea of irritating these joints by means of setons, from what had been done by Mr. Hunter," an insinuation unlikely and unjust. Mr. White, of Cherry Valley, New York, formerly President of the Medical Society of that State, also advised scraping of the extremities of the bone so as to remove their cartilaginous covering. The same practise is recommended by Van der Haar of Holland. In 1814, M. Barthelemy proposed the use of a rasp, in form of a saw, and conveyed down to the fragments by means of a canula, to scrape the ends of the bone. (*Vallet*, quoted from *Velpeau*, ii, p. 588.) Sir Charles Bell appears to have imagined an instrument of a somewhat

similar kind. In the 2d volume of his *Operative Surgery* (p. 326, 2d edit. 1814) he says, "In one case, I thought myself, by observations made on animals, authorised to propose that a sharp instrument should be pushed obliquely down upon the bone, so as to work upon and penetrate the extremities of the bones. By this means, I imagined the wound made by the passage of the instrument would immediately heal, and yet the extremities of the bone be so excited as to resemble the state of simple fracture more than can possibly happen after cutting down upon them and sawing their ends." The suggestion, however, was never acted on. Mr. Hunter's method of irritating the ends of the bone, is stated to have lately failed in two cases at St. George's Hospital, London. (*Works by Pulmer*, i, 505, 1835.)

14th. *Scraping the ends of the bone and retaining lint between the fractured extremities* was practised by Brodie, in 1834. (*London Med. Gaz. for July, 1834.*)

15th. *Hot Iron.*—Heat applied between the fragments was successfully made use of by M. Mayor in 1828. (*Délégation Chirurgicale.*) He thus describes its mode of application: "The canula of a large trocar was passed between the two oblique fragments of the femur, and left eight hours in place, through which a rounded iron was repeatedly passed, it having first been held in boiling water. By means of this burn at 100° R. I believed that I should be able to inflame the bony surfaces and surrounding tissues, and place them in a proper condition to unite." The case was one of seven months duration, in which pressure and frictions had been uselessly tried.

16th. *Injections.*—The injection of stimulating substances has been adopted in cases of disunited fractures, accompanied by a wound or fistulous opening, by Dr. Hulse of the U. S. Navy. (*American Journ. of the Med. Sciences*, xiii. 1834.) In the case reported by him, port wine and water, salt and water, and a solution of sulphate of copper were successively employed, and a cure effected in two months. A solution of nitrate of silver, dilute alcohol, wine and hot water, have also been proposed as injections into these joints. The rapidity with which a solution of iodine is absorbed, together with its well tested stimulating effects as an injection in hydrocele, would induce me to give a preference to it over other stimulating articles. I am not aware of injections having ever been made use of in false joint unconnected with wound, and though they might easily be introduced in such cases by means of a trocar, yet judging from the severe effects sometimes known to follow the injection of stimulating fluid into the cellular tissue in cases of hydrocele, I should regard their employment as hazardous.

17th. *Resection of the extremities of the bone.* The method of treatment by resection was first brought into notice by Mr. White, of Manchester, in 1760. Petit, however, before this period removed with a trephine the ends of a fractured bone, affected with caries, and the operation is said to have been described as long ago as the time of Avicenna. (*Dictionnaire de Médécine*,

xiii. p. 503, 2d ed.) The case in which this practice was first tried by Mr. White, (*Cases in Surgery,*) was that of a boy, aged nine years, in whom a pseudarthrosis existed at the humerus of six months standing. His injury had been a simple oblique fracture: the ends of the bone were found to be riding over each other, and the arm was not only useless, but a burden to him. Amputation was proposed for his relief, to which Mr. White objected, and suggested resection of the extremities of the bone and afterwards treating the case as a compound fracture. The patient did not lose above a spoonful of blood in the operation. In about six weeks after it, the callus began to form, and soon after became quite firm.

18th. *Resection of one of the fragments only,* has been practised in two instances by M. Dupuytren with success. This procedure, however, did not, as has been said, originate with him, since we find a case recorded by one of his own countrymen (*Mémoires de l'Acad. Roy. de Chirurgie,* iv, p. 113, 8vo. Paris, 1819), in which resection of an inch of the inferior end of a non-consolidated fracture of the femur, was made in 1758, with a view to procure union of the fragments. White also, in a case situated in the tibia, and Inglis on the same bone, employed excision of the superior fragments only, with success, long before the time of Dupuytren.

19th. *Excising the ends of the bone, and afterwards engaging the point of one of the fragments in the medullary canal of the other,* so as to maintain the extremities in contact, has been done by M. Roux. (*Bérard, Thèse,* p. 53.) No accident followed the operation, but it is stated that at the end of two months a fall upon the fractured arm prevented any benefit from the treatment, and necessitated the amputation of the limb.

20th. *Exposing the ends of the bone and rubbing them over with caustic.* The proposal to apply caustics to the fractured extremities, originated with Mr. White of Manchester. The case in which he adopted it was an un-united fracture of the leg of nine months standing, and in it the extremities of the bone were sawn off, and about a week after, the ends were touched with the butter of antimony. A slight exfoliation occurred, and the patient recovered with a firm limb. Mr. Henry Cline, of London, was, I believe, the first who made use of caustic, without having recourse to previous removal of the ends of the bone. His case was successful. Mr. Earle, in 1821, made use of it in two instances, (*Med. Chir. Trans.* xii, 1822,) though without success: one of these was in a case of ten months duration in which the seton had previously failed. After the application of the caustic, callus was deposited, and the limb became much stronger, but this was afterwards absorbed. The fracture in his second case, (produced by the lifting of a tea-pot,) was of nine years standing, and occurred in a patient "worn out with mercury," in whom nearly every cylindrical bone in the body was diseased: a case evidently unfitted for any operation. In 1827, Dr. Hewson applied the caustic potash to an old fracture of the leg, after removal of the ligamentous matter connecting the fragments, with the happiest effect. (*North American Med. and Surg. Journ. for January, 1828,* p.

11.) At the end of eight weeks cicatrization of the wound had taken place, and after twelve weeks the fragments were firmly consolidated. Another ununited fracture of the tibia, successfully treated by the butter of antimony, has been reported by Lehmann. (*Graefe & Walther*, iii, 2<sup>e</sup> cah. 1822, quoted from *Bérard*.) The caustic in his case was applied after removal of the matter separating the ends of the bone; four weeks afterwards some small pieces of bone were discharged, and in a short time the patient was able to make use of his limb. The same caustic has been used with good effect in an instance reported by Weilinger. (*Oppenheim, op. citat.* p. 8.) Ollenroth touched the fractured extremities with fuming nitric acid and was successful. (*Oppenheim, op. citat.* p. 7.) The caustic potash has been successfully used in three or four cases by Dr. J. R. Barton, of this city, in one of which, (following a compound fracture of the leg of 16 or 18 months standing,) Dr. Physick discouraged the employment of the seton from fear of its failure. I have myself, in a case of want of union in the humerus of four years duration, employed the potash with the most perfect success. (*Surgical Report of Pennsylvania Hospital, Am. Journ. of Med. Sci. for Feb. 1839.*)

21st. *Actual cautery*.—Petit describes the case of a youth affected with ulcer and caries of the tibia at its middle, which became the seat of fracture, the fibula remaining whole, in which he cauterized the extremities of the bone, and afterwards took off the carious parts with a trepan; having done this, he applied lint to the naked bone, well saturated with tinct. aloes: at the end of fifty days the diseased bone separated from the sound portion, after which union occurred.—(Quoted from *Heister's Surgery*, ed. 1743, p. 114.)

22d. *Removing the extremities of the bone and connecting the fragments by means of wire*.—The tying together of the fragments in recent fractures of the lower jaw, where there is a difficulty of retaining the ends in contact, by means of a silver or other wire passed around the teeth, has been recommended since the days of Hippocrates. In 1818, M. Dupuytren practised this method upon a case of an ununited fracture of the lower jaw, which had existed nearly three years. (*Leçons Ordinales*, iv, p. 669). In this instance, he resected the posterior fragment, rasped the anterior, and secured the fragments in close apposition by means of a platina wire passed around the teeth. The application of this procedure to fractures of long standing, however, did not originate with him; the same practice having been pursued in 1805 by M. Horeau in a similar case. (*Journ. de Méd. Chir. and Pharm. in 40 vols.* x, p. 195, 1805.) The idea of securing the long bones in close contact by connecting them with wires, in cases of recent compound fractures, was also proposed and practised before the time of Horeau, by a surgeon named Icart. His method was to surround and draw closely together the fragments by means of a metallic ligature, for the purpose of preventing displacement; and states that he has seen it put in execution with success. (*Journ. de Méd. Chirurg. and Pharm. par M. A. Roux*, xlvi, p. 167, 1776.) The practice,

however, was strongly reprobated by his brother practitioners, particularly by Pujol, in the journal above quoted, as well as in a memoir upon the subject published about the same period. For an ununited fracture of the patella it was proposed, as far back as the time of M. A. Severinus, to freshen the ends of the bone, and afterwards tie them tightly one against the other, (*Velpau, op. citat.* ii, p. 591,) and a well known surgeon of a sister city, Dr. J. Kearney Rodgers, has recently revived this practice, (*New York Journ. of Med. and Surg.* i, p. 343, 1839—paper by Heard,) and has in several instances drilled holes through the extremities of the bone, and then brought them together by means of silver wire. The object of the wire is to bring the fractured fragments in contact, and so retain them. We cannot conceive it possible that it should ever be found a difficult matter to bring the fractured fragments in apposition after resection of their ends. The loss of bone has been in those instances we have witnessed, and must, we judge, always be, sufficient to allow of their being so placed by position and a proper apparatus alone. The drilling of holes, and fixing of wires to the bones, besides lengthening an operation which is always tedious and painful, must necessarily expose them to denudation of the periosteum, and consequent caries or necrosis. We have never had an opportunity of witnessing this operation, but all theoretical reasoning would lead us to condemn it. One instance has come to our knowledge in which the operation of Severinus (on the patella) was put in execution, and a fatal result followed on the fourth day. Malgaigne, writing in 1840, erroneously gives the credit of this mode of operating to M. Flaubert of Rouen, who, he says, had performed it on the humerus a short time previously with a satisfactory result. (*Op. citat.* p. 249, 3d ed.)

23d. *Amputation*.—In ununited fractures, as in all other cases coming under the care of the surgeon, amputation is his last resource; it should never be resorted to in pseudarthrosis, except after the failure of every other means, and then only when it renders the life of the patient miserable, and he himself demands it.

The few pages devoted to the consideration of non-consolidated fractures in our treatises on surgery, are for the most part extremely vague and unsatisfactory; and in practice, the various modes of treatment recommended for their cure are resorted to without discrimination, according to the particular fancy of the surgeon. The methods that we have enumerated, have all at different times been much vaunted by practitioners, and, as might be expected, have all in some instances been followed by failure. One of the British writers, who appears to have devoted most attention to the subject of these affections, is of opinion that all modes of treatment have been very unsuccessful; so much so, that he thinks he is far within the mark in stating, that not one in twenty in which they are tried is followed by a favourable result. This statement is based upon recollection alone: though not very unfrequent, the failures are believed not to be so numerous as is here stated. Our tables

show, that out of 150 published cases, 113 have been cured. In their treatment no exclusive method should be adopted; all may at times be applicable, and may be regarded as good or bad, according to the particular condition of the parts in each individual case. In making choice of a plan of treatment, we should be governed by the situation of the injury—whether near a joint or otherwise—the limb affected—the length of time which the fracture has existed—the degree of mobility existing in the fragments—whether the fragments be in apposition or otherwise—whether connected by a ligamentous band, or united by means of a preternatural capsule, should be carefully ascertained before the kind of operation to be employed is decided upon. The five following classes will embrace all the modes of cure most commonly resorted to, and the particular cases to which these are applicable, together with the main objections which at different times have been urged against them, we shall now briefly enumerate.

1. Compression and rest. 2. Frictions. 3. Seton. 4. The application of caustic to the seat of fracture. 5. Resection of the ends of the bones.

1. *Compression and rest.*—Commonly speaking, the terms ununited, or disunited, when applied to fractures, are used simply to express that the bones bend and have not become firm at the injured part, without reference to the length of time that has elapsed since the occurrence of the accident, or the state of the fragments which exists; and many cases are reported which were cured by continuing the application of the apparatus employed, without requiring any further assistance from the surgeon. Properly speaking, the union in these cases is simply delayed; and it is to these delayed consolidations that the treatment by rest and compression is peculiarly applicable. Besides these, compression and rest is always adapted to, and will be likely to prove successful, in cases of non-union in which the cause can be attributed to motion, or want of proper position after the recent fracture, where the ends of the bones are not absorbed and are connected by fibro-cartilaginous substance, into which sufficient bone has not been deposited, or to cases where no sort of union has taken place in consequence of previous want of perfect apposition, provided the ends can be brought into contact, and they have existed but a few months. To cases, also, which are accompanied by an inflammatory state of the fragments of the fractured limb, this treatment is well suited. In all of the first mentioned order, it must be evident that the chances of union become probable when the broken bones are brought into contact and so retained; and in the latter, consolidation will be apt to occur upon the subsidence of the increased action in the limb, consequent upon its being placed in a state of perfect quietude. As the method is unattended with danger, it should always be resorted to in instances of the kind mentioned, particularly when in young subjects, previous to performing any of the more serious operations which have been proposed for remedying this accident. In cases where there exists an approach to a capsular ligament, or where the ends of the bone are diseased, or are prevented from uniting by the interposition of a foreign substance, or are rounded and sepa-

rated, though connected by means of ligamentous matter, the mere influence of pressure and rest are not alone sufficient to produce a cure. Where pressure directly over the seat of fracture is made use of, the tourniquet is preferable to the roller, as by means of the screw a more equable degree of pressure can be kept up, and if pain or other unpleasant symptom follow its application, can be loosened without putting the surgeon to inconvenience. Of late years, pressure and a state of perfect repose has been sometimes produced by the immovable apparatus, which, if ever to be approved, is in the class of injuries that we are now treating of.

Out of 36 cases included in our table, treated by pressure and rest, 29 were cured. Of these,

13	were in the femur, of which	9	were cured.
7	" leg, "	7	"
12	" humerus, "	9	"
4	" fore-arm, "	4	"

The longest period that the fracture had existed in these cases was 22 months, (femur, *at. 27.*) The shortest period was 4 weeks, (fore-arm, *at. 12.*) The average period was 5 months and 12 days. The longest period required for a cure was 5 months, (humerus, *at. 24.*) The shortest period was 18 days, (femur, *at. 25.*) The average period was 9 weeks.

In the 36 cases in which pressure and rest was employed, accidents depending upon the treatment, and not terminating in death, are stated to have occurred four times—(excoriations 1, severe pain and inflammation 3.)

2. *Frictions.*—In making use of frictions, the object aimed at is to break up any ligamentous bands that may unite the fragments of the bone, and by rubbing these together destroy any covering which they may have, and produce a degree of irritation as great as would follow a recent fracture. Boyer denounces the use of frictions, believing that if deposition of callus has commenced, rest alone will be sufficient for the cure, and if a false joint is already established, the frictions will be totally without benefit, and will, besides, expose the patient to serious accidents from the contusion and tearing of the surrounding soft parts. (*Op. citat. iii, p. 106.*) Before the time of Boyer, Duverney had pronounced this method to be only good in the study, "for however the whole end of the cemented bone be rubbed, it is useless and even dangerous to the patient." (*Diseases of the Bones*, transl. by Ingham, p. 176.) Kluge permits his patients to use a limb if it still remains flexible after the lapse of time usually occupied in consolidation, and when inflammation is thus excited, he restores it to its previous quiescent state. (*Oppenheim, op. citat. p. 4.*) In every instance a quick and firm consolidation resulted.

Experience proves that where there is simply tardiness in the formation of callus, the method by friction, though it has often failed, may be serviceable; and as with the exception of the case reported by White, in which abscess followed, we are not aware of any instance ever having been reported in which unpleasant symptoms were produced by it, would advise a trial being

made with it after compression has failed, before resort is had to any more severe measure. Frictions, however, in such a degree as to risk serious injury to the surrounding parts are unwarrantable, nor should they ever be employed where any degree of union has commenced, until it is well ascertained that nature unassisted is incompetent to produce firm union, as we know that motion will sometimes cause rapid absorption of the matter effused between the ends of the bone. On this account the practice advised by some surgeons, where union is tardy, of removing all apparatus and allowing the patient to move his limb freely while in bed, is to be deprecated as being doubtful in its results.

The treatment by frictions is particularly applicable to the cases described in our second order, where the fracture has been nearly transverse and union of no sort exists between the fragments. In most instances of our third order, the fibro-ligamentous connections between the fragments is so strong as to prevent a fair trial of this means; but such cases would probably all be cured by rest and compression. Of the two methods of making use of frictions, preference should, we think, be given to that of seizing the extremities of the bone and rubbing their ends together, as by it, frictions are more effectual, and the liability to danger less imminent, than in binding up the limb and suffering the patient to move about upon it. Where, however, the degree of motion is slight, the latter mode may be advantageously employed. The necessity of a state of perfect rest, after a sufficient degree of irritation has been once set up, has been already stated, and is highly important.

In addition to the cases cited in the accompanying tables in which frictions have been used, the method has been employed successfully by Briot, (*Malgaigne*, p. 248;) by Champion, (*Velpeau, op. citat.* ii, p. 683,) in a leg after two and a half months. Jacquier d'Ervy, (*idem*,) in a leg; Vogel, (*idem*,) in a clavicle; Base Dow, (*Bérard, op. citat.* p. 44,) in a leg after five weeks. Steinheim, (*Oppenheim, op. citat.* p. 5,) in a femur. Sanson, (*Dict. de Méd. and Chir. Prat.* iii, p. 500,) in a femur of more than a year's duration; by Ashmead, (*communicated to author*,) in two cases in the leg after the lapse of several months; and by Kirkbride, in a humerus that had failed to unite at the end of three months. (*Am. Journ. of the Med. Sci.* xv, 1835.) Bonn, Germain, Hain, Ansiaux, and others, have, however, failed.

.3 *Seton*.—From its first proposal by Dr. Physick, the use of the seton has received continued opposition, both in England and France. By authoritative writers of these countries, it is stated most generally to have failed in producing union. Mr. Amesbury, writing in 1829, thus expresses himself in regard to it:—"I have seen three cases of non-union treated with setons —one in the femur and two in the humerus. The constitutional disturbance produced by the seton in the thigh was extremely severe: but the irritative fever occasioned by it in the other two instances was not great. Not the least benefit was obtained from its employment in either case." He adds, "Though I have heard of many cases of non-union treated by

the employment of setons, I am not aware that there are more than three treated in this country, where its operation appears to have brought about consolidation of the bone." (*Op. citat.* p. 224.) Another high authority, Mr. Lawrence, remarks (*Lond. Med. Gazette*, vi, p. 355, 1830)—"I believe it may be said that there are some two or three instances recorded, in which after some weeks or months of confinement, with a good deal of pain and danger, the union has been effected in this way; but in other cases the introduction of the seton has failed." Speaking of the seton in his lectures, in 1833, Brodie mentions his having used it in three cases. The first was in an ununited fracture of the femur, and union took place though it was not completed until after a long period of time. The second case, also of the femur, was followed by so much disturbance of the constitution, that he became alarmed, and the seton was removed. The symptoms after this subsided, and it was re-introduced and kept in for a length of time, but no cure was effected, and the patient left the hospital with the bones as loose as when he was first admitted. In the third case the injury was in the clavicle, and was of many years standing, and here a perfect cure was accomplished after the use of the seton for several weeks. He then adds, "The result of the practice in England appears to be, that sometimes it has succeeded in the upper extremities, but that where it has been performed on the lower extremities, as far as I know, it has only succeeded in a single instance, viz. that of the patient under my care." (*Lond. Med. Gazette*, xiii.) Mr. Palmer, (*Edit. of Hunter* i, p. 505, 1835, note,) writing in 1835, speaks of its having succeeded "in a few cases." Syme thinks the irritation determined by the presence of a seton cannot be useful but when there is a commencement of union. (*Edin. Med. and Surg. Journ.* July, 1835.) M. Sanson summarily condemns the treatment with the seton, and advises its rejection. (*Dict. de Méd. and Chir. Prat.* iii, p. 504.) Larrey says he would never recommend the seton or resection, in these cases; (*Clin. Chirurg.* iii, p. 460;) and M. Velpeau (*op. citat.* ii, p. 587) describes it as a very uncertain method of treatment, and gives a preference to the operation of resection, if frictions, or the immovable apparatus, are not sufficient for the cure. The opinions expressed by the above quoted gentlemen show the estimation in which the method is held by many in Europe. Most erroneous notions of the estimation in which the seton continued to be held after an experience of many years, by its discoverer, as well as of the opinions entertained of it by the great mass of surgeons in this country, are at this time circulated abroad. In some editorial remarks of one of the late French Journals, (*Gazette des Hôpitaux*, No. xlix, p. 196, 1839,) it is gravely asserted that in the United States so little benefit has been derived from the employment of the seton in false joints, that it is now no longer employed there—Dr. Physick himself having renounced the treatment during the latter years of his life. We have authority for stating that up to the period of his death, Dr. Physick always advocated the treatment of these

cases by the seton, and may safely assert, that results in America have proved it one of the safest, least painful, and most effectual, of the numerous operations that are performed for the cure of pseudarthrosis.

Much difference of opinion prevails, not only as to the mode of applying the seton, but also as to the length of time which it is necessary to allow it to remain in place. Dr. Physick recommends it to be passed through the integuments and between the ends of the bone, by means of a long seton needle armed with a silk ribbon, or French tape, without previously cutting down to the bone, and advised that it should be left in place for four or five months, or longer. (Hays, in *Am. Journ. Med. Sci.* Nov. 1830, p. 271.) Other practitioners, however, have preferred that the soft parts should be first divided, so as to expose the seat of the fracture, and that it should be removed at the end of a week or two. The first method of operating, as being less painful, and attended with less danger, should, we think, be preferred. The length of time the seton should be allowed to remain, it is impossible to fix upon, but as the object of it is to excite action in the bone, and parts around, and not to promote suppuration, which we know in compound fractures often prevents the union, it would seem that it should be removed without regard to time, as soon as a considerable degree of action is excited, and before excessive suppuration is established. After its withdrawal the limb should be splinted with great attention, and every possible care taken, to keep it in a state of perfect quietude. The seton is especially suited to those cases of preternatural joint which occur in the upper extremities, inferior maxilla, and clavicle, where the fragments can be placed in opposition. In the femur it has often failed; Dr. Physick has tried it in three cases of artificial joint in this bone, without satisfactory results. The experience of Sir B. Brodie, as we have seen, is to the same effect. The cause of failure in these cases is probably owing to its inadequacy in the larger bones to excite a degree of inflammation sufficient to give rise to ossific action. One of the cases in which the seton failed in the hands of Dr. Physick, was that of an adult male who was admitted into the Pennsylvania Hospital, Feb. 17th, 1810, with an artificial joint of the femur following an oblique fracture of the bone just below the trochanter major. His accident had happened eight months previously. On the 28th an incision down to the bone was made over the seat of the fracture, and a seton introduced. On the fourth day, fever and retention of urine followed, but soon disappeared. On the 20th of April an extensive abscess formed in the thigh, and his health had become in some degree impaired. On the fourth of July, on account of the fever, diarrhoea, and debility of the patient, the seton was removed, having been allowed to remain four months and four days, without producing any bony union. (*Penn. Hosp. Case Book*, i, p. 108.)

The situation of the fragments—their being widely separated, or placed in such a direction that they cannot be readily kept in contact; or the abun-

dant deposit of callus about their extremities, may be obstacles, sometimes insurmountable, to its use. The existence of great malposition in the fragments will generally preclude its employment. Close proximity of the fracture to the main artery and nerve, or to an important joint, may also at times prevent a trial with the seton. Where the bone has been for years disunited, and the fracture is very loose, or presents irregular surfaces, the seton is entirely unsuited. In all other cases, it should be preferred to all other operative procedures, as in case of a failure with it some of the more serious operations may always be resorted to. Weinhold (*Med. Recorder*, xiii) imagines that the principal cause of failure with the seton (as used in Europe in connection with an external incision) is, its permitting the access of the external air to the extremities of the bone, which for that reason, are extremely disposed to become carious; and to obviate this he proposes making the wound funnel-shaped, and using a conical or wedge-like seton. In addition to the cases treated by the seton which have been already alluded to, or are included in our tables, this method of treatment has been successfully used in the fore-arm by Delpech, (*Clin. Chir.* i, p. 255,) in the leg by Rigal de Gaillac, in the clavicle by Randolph, and by Saurer in the leg in a case of eight months duration. (*Oppenheim, op. citat.* p. 15.) In the case of a non-united fracture of the humerus, cited by Lombard, (*Velpeau, op. citat.* ii, p. 586,) it was employed without benefit, and on the same bone with only partial success, by Béclard of Strasburg. An ununited fracture of the acromion process of the scapula, occurring in a female, which was treated by the seton some years back at the Alms House Infirmary of this city, terminated in death. Professor Mott's experience in the use of the seton has been large: eleven cases have been treated by this method by him, of which three were of the femur, three of the tibia, and five of the humerus. In all it succeeded perfectly except in three of the last mentioned bone, which were afterwards cured by resection of the ends. (Vaché, in *Am. Journ. of the Med. Sci.* ix, p. 262.)

Reference to the tables appended to this paper exhibits the following results in 46 cases in which the seton and its modifications were employed. Of these,

13 were in the femur, of which 9 were cured.

10	"	leg,	"	10	"
16	"	humerus,	"	10	"
6	"	fore-arm,	"	6	"
1	"	jaw,	"	1	"

Of these 46 cases, 21 are stated to have had an incision made down to the bone previous to the introduction of the seton, and 24 had it passed without a previous incision. Of the 21 where previous incision was made, 17 were cured, 2 amended, 1 failed, and 1 died. Of the 24 in which there was no previous division of the soft parts, 18 were cured, 1 amended, 4 failed, and 1 died.

In one case the seton was passed through a fistulous opening which previously existed.

The longest period that the fracture had existed in these cases, was 10 years, (femur, et. 26.) The shortest period was six weeks, (tibia, et. 48.) The average period was 12 months and 12 days.

The longest period that the seton was allowed to remain, was 13 months, (humerus, et. 48, failed.) The shortest period was 7 days, (fore-arm, cure.) The average period was 7 weeks and 3 days.

The longest period required for the cure was 8 months, (femur, et. 41.) The shortest period was 3 weeks, (humerus, et. 23.) The average period was 2 months and 24 days. In 17 of the cases in which the seton was employed, other methods of operating are stated to have been tried and to have failed.

In the 46 cases treated by the seton, accidents dependent upon the method employed, and not terminating in death, are noted as having occurred 12 times, (arterial hemorrhage twice; severe fever, erysipelas, or profuse suppuration, 10 times.)

4. *The application of caustic to the seat of fracture.*—The application of caustic to the ends of the fractured bone after free exposure of them, is a more powerful means of effecting the requisite irritation in the periosteum and bone than the seton, and seems worthy of more extensive employment than it has heretofore received. From the ease with which the operation can be done, the little pain attendant on it, and the almost certainty of producing by it a degree of action in the parts sufficient to excite a deposit of callus, without at the same time keeping up that action so long as to cause excessive suppuration, which often leads to failure, I am induced to prefer it to excision of the ends of the bone, and would recommend it in those cases which are rebellious to the simpler modes of treatment, viz. compression, frictions, and the seton. In performing the operation, the seat of fracture is to be fairly exposed, the substance connecting the ends of the bone divided, and the wound carefully dried; after which the caustic is to be freely rubbed over them until a black eschar is formed. The wound should then be filled with lint, and the limb placed in a state of the most absolute rest.

The operation with the caustic is as applicable to the lower as the upper extremity, and is the only procedure, except resection, that is well suited to cases which have been for years disunited, or are very movable, and surrounded by a preternatural capsule.

Different caustics have been made use of in these cases. White and Lehman employed the butter of antimony. Ollenroth has proposed the nitric acid. In the cases reported by Cline, Earle, Barton, and myself, the caustic potash was used, and is, I think, preferable.

5. *Resection of the ends of the bone.*—This method of treatment, though it has been frequently adopted with success, is nevertheless attended with great danger. All writers who have practised it acknowledge its severity, and few recommend its employment except in extreme cases. Mr. Lawrence thus

notices resection: "This is a serious proceeding; indeed, in the middle of a fleshy limb, as the thigh for example, it must be a very difficult thing to accomplish." (*Lond. Med. Gaz.* vi, 1830.) Boyer describes it as one of the most serious operations in surgery, and speaks of it as "painful, bloody, and of uncertain success." (*Maladies Chirurgicales*, iii.) Barton views it as difficult for the surgeon, besides being painful, and of doubtful result both to the limb and life of the patient. (*Med. Rec.* ix, p. 276, 1826.) Liston regards it as a "difficult and severe process," (*Lancet*, ii, 1835-6, p. 169,) and states that he has never attempted the operation but once, and then failed in procuring union. Somm<sup>e</sup> mentions an instance of ununited fracture of the arm, in which he witnessed the operation of amputation of the fractured extremities without any benefit resulting, and pronounces the method "barbarous," and thinks "it ought to be rejected from surgical practice." (*Med. Chir. Trans.* xvi, p. 39.) Gouraud looks upon it as a retrograde step in surgery, (*Méd. Op. Velpeau*, ii, p. 589, Paris, 1839;) and M. Velpeau, though an advocate for this mode of treatment, candidly exposes its great dangers. We should never, says he, "decide upon this operation without having well considered it. Requiring a deep and large incision into the soft parts, it places the bone in the state of a recent fracture accompanied with severe wound, from whence results the danger of excessive suppuration, erysipelas, caries, necrosis, as well as of purulent absorptions, and phlebitis." (*Idem.* ii, p. 592). Jourdan thinks that resection is only practicable on the humerus, or at furthest on the femur, and that the accidents which terminate almost always in death should make us prefer amputation. (*Dictionnaire des Sc. Méd. art. Fausse Articulation.*) Mr. Rowlands, after reporting a case in the femur successfully operated on by resection of the ends, states, that the operation far surpassed in severity "anything I had ever undertaken or witnessed, and I am doubtful as to the propriety of recommending it to others." (*Med. Chir. Trans.* ii, p. 49.) On the femur this operation is particularly severe, and the great length of time required for its performance on that bone, is alone, in debilitated patients, a sufficiently strong objection to it. In a case of resection of the thigh bone noticed by M. Vallet, (*Méd. Op. Velpeau*, ii, p. 589,) the operation is stated to have been of extreme severity, and to have lasted more than an hour: the patient, who was young and vigorous, had convulsions, and died the same evening. In the case of Walb, reported by Dr. Kirkbride, (*Am. Journ. Med. Sc.* xvii, p. 46,) the operation lasted near two hours, the patient afterwards dying of absorption of pus on the sixteenth day. And in a patient that I saw operated upon at the Pennsylvania Hospital in 1833, the operation was tedious and painful, though after a long confinement and exposure to great dangers, he was finally cured. Speaking of the treatment of ununited fracture by excising the ends of the bone, Mr. Crosse observes, that he has known excision cure; "but it so often fails as to render the practice very discouraging," (*Retrospective Address*, p. 80,) and M. Sanson thinks that "all prudent practitioners will agree

that it is better to leave the patient with his infirmity, which in no way endangers life, than seek to remove it by an operation which greatly perils it." (*Dict. de Méd. and Chirurg. Prat.* iii, p. 505.)

The mode of treatment by resection is more particularly applicable to such fractures as are accompanied with great deformity, or have been for a very long period disunited, and have the ends of the bone very widely separated and loose, or such as are surrounded by a preternatural capsular ligament, with the fractured ends enlarged, than to those cases in which the ends of the bone are connected together by a ligamentous band only. It is better adapted to parts in which but a single bone exists, as the humerus and femur, than to the fore-arm, or leg. As with the seton, and other methods of treatment, it must necessarily fail where the want of consolidation arises from any constitutional cause. Where the preternatural joint is near to an important articulation, it is altogether inapplicable. By some writers it has been thought to be peculiarly suited to such pseudarthroses as are produced by a necrosed state of the extremities of the fragments; but in these cases, as a general rule, any very serious operation is unjustifiable, experience teaching us that it is better to leave the removal of the bone to nature, and in no way interfere until the diseased parts are separated by the absorbents, when they should be removed, and the limb afterwards supported as carefully as in cases of recent fracture. A cure by resection, it is to be remembered, is always accompanied by more or less shortening of the limb—a slight inconvenience for the arm, but a matter which should enter into our calculations when the lower limb is the seat of the infirmity.

In performing the operation of resection of the ends of the bone, a longitudinal incision is to be made opposite to the point of fracture, and in that part of the limb in which the bone is most superficial, care being taken at the same time to avoid the neighbourhood of large arteries or nerves. The surrounding soft parts are then dissected from the extremities of the fragments, and successively pushed out and removed with a saw, no more of the bone being taken away than is absolutely required. The ends of the bone are afterwards to be brought in contact, and the limb so placed as to favour the discharge of pus from it, care at the time being taken to retain it at perfect rest, and to treat it in every respect as a severe compound fracture.

Personal examination, and a close examination of most of the recorded cases of excision of the ends of the bones, leads one to regard it, particularly in the femur, as an operation of so formidable a nature, both as to the risk incurred by the patient, and the great amount of suffering that it gives rise to, that it should never be resorted to until all other modes of treatment have failed, or are from some peculiar circumstances inapplicable.

In addition to the instances elsewhere noticed by us, resection has proved successful in the hands of Josse, (*Mél. de Chirurg. Prat.* p. 321,) Hysern, (*Méd. Opérat. of Velpeau*, i,) Andrews, (*Lond. Med. Journal*, 1781, i,) Dupont, (*Archives Générales*, ii, p. 628, 1823,) and Langenbeck, (*Cooper's*

*Surg. Dict.*) on the humerus: with Fricke (*Méd. Opérat.* of *Velpeau*, ii, p. 590,) and Holscher (*Oppenheim*, p. 11,) on the fore-arm; with Dubois, (*Velpeau*, ii, p. 590,) Josse, (*Mél. de Chir. Prat.* p. 311,) Dupuytren, (*Thèse of Bérard*, p. 52,) and Düsterburg, (*Oppenheim*, p. 11,) in the leg; and with Viguerie (*Larrey, Military Surgery*, trans. by Hall,) and Moreau, Jr. (*Méd. Opérat.* of *Velpeau*, ii, p. 590,) upon the femur.

Mr. Amesbury has seen the operation of removal of the ends of the bone twice unsuccessfully performed in the humerus. The first was a man of strong constitution, who, after many months confinement, was allowed to get up. He saw him eighteen months after the operation, when the wound had healed, but the arm was much worse than when it was performed. In the second instance, after many months suffering from exfoliation and abscesses, the man left his bed with the limb much worse than before. (*Op. citat.* p. 216.) Dupuytren lost a patient after this operation on the humerus, and derived no benefit from it in another case on the same bone. (*Gaz. Méd.* 1831.) Mr. James has employed it in the arm unsuccessfully. (*Retrospective Address—Prov. Med. and Surg. Trans.* viii, 1840.) Viricel lost a patient a few days after rasping the fractured extremities. (*Velpeau, op. citat.* ii, p. 587.) Mr. Allan knew the operation to fail in the hands of John Bell, whom he assisted in a case on the humerus of twelve months' standing, (*System of Surgery;*) and Physiek mentions an instance in which it was performed unsuccessfully upon the humerus, and states that the patient afterwards entered the hospital in this city, where the limb was amputated, and related to him the great suffering which he had experienced in the operation of excision. (*MS. Notes of Lectures.*) Resection has also altogether failed in the hands of Ansiaux, (*Velpeau, op. citat.* ii, p. 590,) Moreau, (*Idem,* *idem,*) Beck, (*Jæger's Thesis on Resections,*) and Roux, (*Thèse of Bérard,* p. 53,) on the humerus, with Warmuth, (*Oppenheim*, p. 11,) on the ulna; and Dr. Güntz, of Leipsic, (*Idem*, p. 12,) mentions two instances of failure after resection, of false joints, without specifying the bones operated on.

Of the 38 cases in the table in which resection was performed, 24 were cured, 1 amended, 7 failed, and 6 died. Of these,

12 were in the femur, of which 7 were cured.

6	"	leg,	5	"
12	"	humerus,	6	"
7	"	fore-arm,	5	" and 1 amended.
1	"	jaw,	1	"

The longest period that the fracture had existed in these cases was 5 years. (Adult—Femur.) The shortest period was 10 weeks. (Humerus, æt. 50.)

The average period was 13 months and 19 days.

The longest period required for the cure was 13 months (femur, æt. 26).

The shortest period was 1 month (fore-arm). The average period was 4 months.

In 17 of the cases in which resection was employed, other methods of operating are stated to have been tried, and to have failed; of which the seton was used 6 times.

In the 38 cases in which resection was resorted to, accidents dependent upon the treatment followed, and not terminating in death, occurred 9 times, (erysipelas, 6; profuse suppuration and abscesses, 2; phlegmasia dolens, 1.)

From all that has been observed in the preceding pages upon the treatment of ununited fractures, it will be seen that we recommend:

1<sup>st</sup>. To apply the method of cure by rest and compression. If the fracture has been regularly treated, and is not consolidated at the usual period, replace the limb in the apparatus, and insure to it a state of complete immovability: if the treatment of the injury has been altogether neglected, or been inefficient, apply proper splints and moderate compression with a roller, and renew these as soon as they become in any degree lax.

2<sup>d</sup>. If from want of action in the seat of injury, rest and compression are in themselves insufficient to produce a cure, continue the state of immovability in which you have placed the limb, and apply blisters, moxas, iodine, or some other stimulant to the seat of fracture.

3<sup>d</sup>. If both of these modes fail in producing a deposition of callus, employ frictions.

4<sup>th</sup>. If the methods mentioned fail to produce a change, or the patient has already been suffering from his injury for eight or ten months, and there is no contra-indication to it, resort to the seton.

5<sup>th</sup>. If the case be one to which, from its long standing, or state of the injured parts, the seton is inapplicable, expose the fracture, and apply caustic potash to the fractured ends.

6<sup>th</sup>. If all the above means have been carefully resorted to unsuccessfully, and not till then, resect the ends of the bone.

7<sup>th</sup>. Never resort to amputation of the member until fair trials have been made with all of these methods, and then only at the request of the sufferer, after he has found that the limb can be of no possible service to him.

In employing any of the above means, the obstacle to the occurrence of union which may exist, arising from the state of the constitution, should be carefully sought for and combated by an appropriate treatment.

#### APPENDIX.

The accompanying table, arranged in such a manner as to exhibit the chief points in each individual case, together with the sources from whence they are derived, is added in proof of the remarks made in the foregoing pages. No reference is given which I have not myself examined, and the collection, so far as the American, English, and French journals, and surgical works are concerned, will be found tolerably complete. A number of cases might, I doubt not, be added from the German, and it is a source of much regret, that but few works in that language were within my reach.

No.	Work.	Surgeon.	Sex.	Age.	Seat of Fracture.	Period it has existed.	Operation.	Accidents which followed.	Length of time seton remained.	Duration of treatment.	Termination.	Methods of cure which had previously failed.
1	Med. Chir. Trans. vi.	Rowlands	Male	53	Penetr	5 months	Resection	Arterial haemorrhage and erysipelas	5 months	5 months	Perfect cure	
2	Med. Chir. Trans. v.	Wardrop	Male	Adult	Penetr	20 months	Seton			Amendment		
3	Med. Chir. Trans. v.	Brodie	Male	13	Penetr	5 months	Seton			Perfect cure		
4	Med. Chir. Trans. vi.	Stanhope	Male	48	Humerus	7 months	Seton			Perfect cure		
5	Med. Chir. Trans. vi.	Boggs	Male	Adult	Tibia	2 months	Seton			Frict. for 5 weeks		
6	Med. Chir. Trans. vi.	Earle	Male	30	Humerus	10 months	Cautic. potash			Failure		
7	Med. Chir. Trans. xi.	Earle	Female	Penetr	Humerus	9 years	Cautic. potash			Failure		
8	Med. Chir. Trans. xii.	Somme	Male	35	Penetr	5 months	Silver wire			Perfect cure		
9	Worl. Med. & Phys. Journ. ii.	Worl. Med. & Phys. Journ. ii.	Male	Adult	Humerus	18 months	Seton			Amendment		
10	Phil. Med. & Phys. Journ. v.	Physick	Male	Adult	Humerus	9 months	Seton			Perfect cure		
11	Phil. Med. & Phys. Journ. vi.	Cittadini	Male	Adult	Fore-arm	14 weeks	Resection			Perfect cure		
12	Amer. Journ. of Med. Sci. xiv.	Dohldorf	Male	24	Humerus	12 months	Resection			Rest and Frict.		
13	Amer. Journ. of Med. Sci. vii.	Auchinloss	Male	18	Humerus	2 months	Resection			Perfect cure		
14	Amer. Journ. of Med. Sci. xiii.	Hause	Male	25	Humerus	6 months	Resection			Failure		
15	Amer. Journ. of Med. Sci. xiv.	Parrish	Male	27	Humerus	6 months	Resection			"A variety of remedies."		
16	Amer. Journ. of Med. Sci. xv.	McDowell	Male	25	Penetr	2 years	Frict.			Failure		
17	Amer. Journ. of Med. Sci. xvii.	Harris	Male	26	Penetr	8 months	Seton			Failure		
18	Amer. Journ. of Med. Sci. xvii.	Harris	Male	24	Fore-arm	8 months	Resection			Failure		
19	Amer. Journ. of Med. Sci. xvii.	Harris	Male	24	Humerus	15 months	Seton			Perfect cure		
20	Amer. Journ. of Med. Sci. xvii.	Barton	Male	30	Leg	16 months	Resection			Seton for 8 weeks.		
21	Amer. Journ. of Med. Sci. xvii.	Newson	Male	24	Penetr	31 months	Resection			Perfect cure		
22	Amer. Journ. of Med. Sci. xxii.	Norris	Male	28	Humerus	4 yrs. & 2 mos.	Cautic. potash			Dieci		
23	Amer. Journ. of Med. Sci. xxii.	Norris	Male	12	Fore-arm	4 weeks	Pressure & rest			Perfect cure		
24	Amer. Journ. of Med. Sci. xxv.	Norris	Male	50	Penetr	7 months	Pressure & rest			Perfect cure		
25	Amer. Journ. of Med. Sci. xxvi.	Fulnestock	Male	23	Radii	9 months	Resection			Perfect cure		
26	Amer. Journ. of Med. Sci. xxvi.	Fulnestock	Male	23	Ulna	14 months	Seton			Perfect cure		
27	Archives Générales.	Portal	Male	24	Humerus	2 months	Amputation			Not stated		
28	Med. Chir. Review viii.	Green	Male	38	Penetr	55 weeks	Amputation			Cured		
29	Med. Chir. Review, xiv.	Green	Male	24	Humerus	2 months	Pressure & rest			Perfect cure		
30	Loud. Med. & Phys. Journ. 1827.	Brodie	Male	44	Humerus	12 months	Resection			Seton		
31	Loud. Med. & Phys. Journ. vi.	Browne	Male	45	Penetr	15 months	Pressure & rest			Perfect cure		
32	Dublin Hosp. Reports. iv.	Inglis	Male	40	Leg	3 months	Resection			Some months		
33	Edin. Med. & Surg. Journ. i.	Inglis	Male	Adult	Penetr	9 weeks	Frict.			5 weeks		
34	Edin. Med. & Surg. Journ. i.	Inglis	Male	Adult	Penetr	5 weeks	Frict.			6 weeks		
35	Edin. Med. & Surg. Journ. i.	Inglis	Male	35	Tibia	5 weeks	Frict.			8 weeks		
36	Edin. Med. & Surg. Journ. i.	Inglis	Female	20	Fore-arm	18 weeks	Resection			Perfect cure		
37	Edin. Med. & Surg. Journ. i.	Inglis	Male	40	Humerus	9 months	Resection			Perfect cure		
38	Edin. Med. & Surg. Journ. xvi.	Macfarlane	Male	20	Humerus	17 weeks	Resection			7 months		
39	Lond. Med. Repository, vi, n. s.	Attenburw	Male	46	Humerus	3 months	Frict.			4 weeks		



No.	Work.	Surgeon.	Sex.	Age.	Seat of Fracture.	Period it has existed.	Operation.	Accident which followed.	Length of time seton remained.	Duration of treatment.	Termination.	Methods of cure which had previously failed.
83	Surgical Essays.	Cooper	Fem.	35	Femur	13 weeks	Pressure & rest	Great swelling of limb	6 weeks	14 months	Failure	Perfect cure
84	Medical Recorder, v.	Ducachet	Male	Adult	Radius	9 months	Seton		14 weeks	6 weeks	Perfect cure	Perfect cure
85	Medical Recorder, vii.	Baxter	do.	do.	Ulna	2 years			12 weeks	12 weeks	Perfect cure	Perfect cure
86	Medical Recorder, ix.	Parton	do.	do.	Tibia	16 months			12 weeks	5 weeks	Perfect cure	Seton for 5 months.
87	N. Y. Med. Journ. i. 1831.	Mott	do.	do.	Humerus	8 months	Rosic & wire				Failure	Perfect cure
88	Trans. Med. & Phys. Soc. v.	Raleigh	do.	do.	Leg	4 months	Pressure & rest				Failure	Resection.
89	Practical Surgery.	Liston	F.m.	48	Humerus	18 months	Seton		13 months	6 months	Perfect cure	Perfect cure
90	Glasgow Med. Journ. iii.	Auchinloss	Male	74	Leg	7 months	Frictions		12 weeks	12 weeks	Perfect cure	Perfect cure
91	N. Y. Journ. of Medicine, i. 1830.	Rodgers	do.	26	Radius	14 weeks.	Rosic & wire				Pressure and rest for 14 weeks, & after wards immovable apparatus for 2 mos.	
92	N. Y. Journ. of Medicine, i.	Cheeseman	do.	28	Femur	9 months	Rosic & wire	Erysipelas	12 weeks	Perfect cure	Frict. & saliv. & set.	
93	N. Y. Journ. of Medicine, i.	Cheeseman	do.	19	Femur	6 months	Pressure & rest		8 weeks	Part. success		
94	N. Y. Journ. of Medicine, i.	Not stated	do.	38	Femur	5 months	Pressure & rest		3 months	On 10th day	Died	
95	N. Y. Journ. of Medicine, i.	Cheeseman	do.	28	Femur	14 months	Amputation			Discharged in dis. of bone	Frictions, and pressure and rest.	
96	N. Y. Journ. of Medicine, i.	Cheeseman	do.	60	Femur	6 months	Amputation			under		
97	Journ. de Ned. Chir. & Pharm., i.	Derecagaxi	do.	44	Leg	6 months	Frictions		17 weeks	Perfect cure		
98	Journ. des Con. Med. Chir. 1838.	Guersant	do.	46	Femur	9 weeks	Amputation		On 7th day	Died		
99	Archives Générales, Jan. 1839.	Seering	do.	52	Tibia	13 weeks	Seton	Severe fever accompanied with acute pain.	6 weeks	Perfect cure		
100	Archives Générales, Jan. 1839.	Seering	do.	37	Femur	2 years	Resection of sup. frag.		At end of some weeks	Died	Seton.	
101	Archives Générales, Jan. 1839.	Seering	Humerus	Not stated			Refusal of all treat.	but was seized with erysip. of limb which produced a violent inflam'mation	1 month	Perfect cure		
102	Dublin Med. Press, ii. 1839.	Rhynsd	Fem.	24	Leg	11 weeks	Seton		1 month	Perfect cure		
103	Lond. Med. Gazette, vi.	Crosse	Male	23	Leg	9 weeks	Painted over with iodine		11 weeks	Perfect cure		
104	Ed. Med. & Surg. Jour. July 1835.	Syme	do.	50	Humerus	10 weeks	Resection	Phlegm. dolens of thigh and leg	7 weeks	Perfect cure		
105	Lancet, for 1827.	Vincent	do.	Adult	Fore-arm	11 months	Raspings ends	Erysipelas	On 5th day	Died	15 days.	
106	Medical Examiner, iii.	McCook	do.	36	Femur	14 months	Resection		3 months	Perfect cure	Pressure & rest and frictions.	
107	Lancet, ii, 1835-6.	Liston	do.	Adult	Fore-arm	9 months	Seton		12 weeks	Perfect cure	Seton for 3 months.	
108	Lond. Med. Gazette, vi.	Crosse	do.	25	Leg	7 weeks	Painted over with iodine	"Good deal of swelling and considerable fever."	6 weeks	Perfect cure		
109	Medical Recorder, ix.	Barton	do.	Adult	Tibia	16 months	Gastric potash Paint, over with iodine & frict.		3 months	Perfect cure		
110	Essay on Non-union.	Buchanan	do.	18	Leg	46 weeks			4 months	Perfect cure		
111	Journ. Complémentaire, v.	Pezenat	do.	32	Femur	13 months			1 year	Perfect cure		
112	Encyclop. des Sc. Méd. Sept. 1837.	Oppenheim	do.	30	Humerus	6 months			6 weeks	Perfect cure		
113	Encyclop. des Sc. Méd. Sept. 1837.	Oppenheim	Fem.	44	Humerus	Some months	Two setons		13 weeks	Perfect cure		communly passed.

No.	Work.	Surgeon.	Sex.	Age.	Seat of Fracture.	Period it has existed.	Operation.	Accidents which followed.	Length of time seton remained.	Duration of treatment.	Termination.	Methods of cure which had previously failed.
114	Gazette Médicale, for 1831.	Dupuytren	Male	37	Humerus	14 months	Resection	Erysipelas	4 months	Failure	Perfect cure	Pressure and rest for 3 months.
115	Med. & Surg. Register, i, part 2	Mott	Male	35	Tibia	7 months	Seton	Friet; blist; electric.	6 weeks	Perfect cure	Friet; blist; electric.	
116	Med. & Surg. Register, i, part 3	Mott	Male	41	Femur	12 months	Seton	Friet; blist; electric.	8 months	Perfect cure	Friet; blist; electric.	
117	Journ. Hebdomadaire, xi & xii.	Dupuytren	Male	23	Humerus	11 months	Res. of sup. frag.	Died	end of 6 weeks	Perfect cure	Pressure and rest.	
118	Garrison's Surgery.	Kennon	Male	25	Leg	14 months	Seton	9 weeks	Perfect cure	Perfect cure	Friction; blisters.	
119	Bos. Med. & Surg. Jour. xiii, 1866.	Warren	Male	25	Femur	3 months	Puncture	3 weeks	Perfect cure	Perfect cure	Friction; blisters.	
120	N. E. Journ. of Med. & Surg. vii.	Thaxter	Male	23	Humerus	6 months	Seton	7 months	Perfect cure	Perfect cure	Friction; blisters.	
121	Chin. des Hôp. du Mid., i.	Depech	Male	22	Radius	12 weeks	Seton	8 weeks	Perfect cure	Perfect cure	Pressure.	
122	London Med. Gazette, ii, 1838-9.	Bennett	Male	18	Femur	10 months	Resection	Absc. & hæc. follow'd & amput'n resorted to	2 weeks	Failure	Frictions.	Frictions.
123	Amer. Journ. of Med. Sci. ii.	Wright	Male	Adult	Tibia	14 weeks	Pressure & rest	Perfect cure	5 weeks	Perfect cure	Perfect care	Pressure and rest.
124	Amer. Journ. of Med. Sci. ii.	Wright	Male	61	Tibia	8 weeks	Pressure & rest	Perfect cure	6 weeks	Perfect cure	Perfect care	Pressure and rest.
125	Amer. Journ. of Med. Sci. ii.	Wright	Male	Adult	Ulna	5 weeks	Pressure & rest	Perfect cure	8 weeks	Perfect cure	Perfect care	Pressure and rest.
126	Macdowell	Larrey	Male	32	Humerus	4 months	Seton	Failure	9 weeks	Failure	Failure	Rest and pressure, and mercury.
127	Clinique Chirurg. i.	Long	Male	Adult	Humerus	Not stated	Resection	A short time	10 days	Rest and pressure for three weeks.	Rest and pressure for three weeks.	
128	Abnethy's Lectures.	Mayo	Male	Adult	Humerus	Not stated	Seton	Failure	5 day	Failure	Failure	
129	Lonsdale on Fractures.	Hays	Male	26	Humerus	3 months	Pressure & rest	Not stated	10 days	Rest and pressure for three weeks.	Rest and pressure for three weeks.	
130	Amer. Journ. of Med. Sci. i, n. s.	Johert	Male	40	Humerus	6 months	Seton	Not stated	5 days	Failure	Failure	
131	Gaz. des Hôpitaux, Sept. 1840.	Donovan	Female	Adult	Fore-arm	3 months	Seton	Not stated	do	Frictions & caustic to inguments.	Frictions & caustic to inguments.	
132	Dublin Med. Press.	Bartishorne	Male	Adult	Fore-arm	4 months	Caust. to integ.	Not stated	do	do	do	
133	Electric Repository, iii, 114.	Hartshorne	Male	24	Humerus	4 months	Caust. to integ.	Not stated	do	do	do	
134	Electric Repository, iii, 114.	Fleming	Female	35	Tibia	14 weeks	Resection	Not stated	do	do	do	
135	London Med. & Phys. Review, i, n.s. 1830.	Wickham	Male	Adult	Femur	5 years	Resection	Not stated	do	do	do	
136	Opérat. of Velpeau, ii, 591.	Halscott	Child	Humerus	11 months	Seton	Not stated	do	do	do	do	
137	London Med. & Surg. Jour. iii, 1830.	Lyford	Female	Adult	Humerus	13 months	Resection	Not stated	do	do	do	
138	do. vi, 1834.	Keate	Male	48	Tibia	6 weeks	Seton	Not stated	do	do	do	
139	Dubl. Med. Press., March 1840.	Enright	Male	30	Tibia	2½ months	Seton	Not stated	do	do	do	
140	Case Book of Penit. Hosp. i, 188.	Physick	Male	27	Femur	8 months	Seton	Not stated	do	do	do	
141	Care Case Book of Penit. Hosp. i, 180.	Bonnet	Male	27	Femur	9 months	Pressure & rest	Several mos.	do	do	do	
142	Gazette Médicale, July, 1840.	Banner	Male	30	Femur	6 weeks	Resection	6 weeks	do	do	do	
143	London Med. Gazette, i, 1837-8.	Green	Male	23	Humerus	10 months	Pressure & rest	9 weeks	do	do	do	
144	Lancet, ii, 1836-7.	Wardrop	Male	35	Fore-arm	7 months	Resection	3 weeks	do	do	do	
145	Lancet, ii, 1826-7.	Fricke	Male	23	Tibia	10 weeks	Seton	10 weeks	do	do	do	
146	Lancet, i, 1829-30.	Donne	Male	28	Tibia	2 years	Rasping ends	10 weeks	do	do	do	
147	West. Journ. of Medicine, 1841.	J. White	Male	15	Femur	15 weeks	Frictions	17 days	do	do	do	
148	Trans. Med. Soc. of N. Y. 1816.	Wopish & Bauer	Female	30	Humerus	30 weeks	Pressure & rest	17 days	do	do	do	
149	Brit. & For. Med. Rev. xii, 1841.	Velpeau	Male	do	do	do	Perfect cure	A few weeks	do	do	do	
150	Med. Opératoire, ii, 555.	Velpeau	Female	do	do	do	Perfect cure	2 months	do	do	do	

## SUMMARY.

Of the above one hundred and fifty cases of ununited fractures,

48 occurred in the Femur, of which 31 were cured, 9 without benefit, 6 died 2 result not stated.

33 " in the Leg, " 32 " 1 " "

48 " in the Humerus, " 31 " 14 " 3 "

19 " in the Fore-arm, " 17 " 1 " 1 "

2 " in the Jaw, " 2 " "

Of 46 cases in which the seton\* was employed, 36 were cured, 3 partial cures, 5 no benefit, 2 died.

" 38 " resection† " 24 " 1 " 7 " 6 "

" 36 " pressure and rest " 29 " 1 " 6 " "

" 8 " caustic " 6 " " 2 "

" 11 " frictions " 11 " "

Of 11 cases in which other methods‡ were employed, 7 were cured, 1 received no benefit, 2 died, 1 result not stated.

The results in the preceding table exhibit, probably, with tolerable accuracy, the success of the seton and resection, though not of the other methods of treatment, which, being milder, were in several of the cases employed before the two just named and more severe ones were resorted to. Thus it would appear as if all the cases treated by frictions had been cured, whereas, in fact, in the 36 cases cured by the seton, frictions had been unsuccessfully tried in 8 of them; and in the 24 cases cured by resection, they had been equally unavailing in 5 of them. This will be seen by referring to the table, but could not be exhibited in the summary without complicating it more than we desired.

Of 112 cases in which the age is noted, there were,

between 10 and 20	-	-	-	-	-	-	14
" 20 and 30	-	-	-	-	-	-	53
" 30 and 40	-	-	-	-	-	-	21
above 40	-	-	-	-	-	-	24

From the tables and summary the following conclusions may be drawn:

1st. That non-union after fracture is most common in the thigh and arm.

2d. That the mortality after operations for its cure, follows the same laws as after amputations and other great operations upon the extremities, viz. that the danger increases with the size of the limb operated on, and the nearness of the operation to the trunk; the mortality after them being greater in the thigh and humerus, than in the leg and fore-arm.

3d. That the failures after operations for their relief are most frequent in the humerus.

4th. That after operations for the cure of ununited fractures, failures are not more frequent in middle-aged and elderly than in younger subjects.

5th. That the seton and its modifications is safer, speedier, and more successful than resection or caustic.

6th. That incising the soft parts previous to passing the seton augments the danger of the method, though fewer failures occur after it.

7th. That the cure by seton is not more certain by allowing it to remain for a very long period, while it exposes to accidents.

8th. That it is least successful on the femur and humerus.

\* Including the methods of Weinhold, Somm , Oppenheim and Seerig.

† Including all cases in which the ends of the bone were scraped, rasped, or excised.

‡ Iodine, 3, all cured; Injections, 1, cured; Erysipelas, 1, cured; Hot Iron, 1, cured; Amputation, 5, 1 cured, 2 died, 1 failed, 1 not stated.